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Annual report of the Governments of Canada, United States, Saskatchewan and Montana.

1991 ANNUAL REPORT

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POPLAR RIVER BILATERAL MONITORING COMMITTEE

COVERING CALENDER YEAR 1991

February 1993

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by the

POPLAR RIVER BILATERAL MONITORING COMMITTEE

COVERING CALENDER YEAR 1991

February 1993

POPLAR RIVER BILATERAL MONITORING COMMITTEE

Department of State
Washington, D.C., United States

Department of External Affairs
Ottawa, Ontario, Canada

Governor's Office
State of Montana
Helena, Montana, United States

Saskatchewan Environment and
Public Safety
Regina, Saskatchewan, Canada

Ladies and Gentleman:

During 1991, the Poplar River Bilateral Monitoring Committee continued to fulfil the responsibilities assigned by the governments under the Poplar River Cooperative Monitoring Arrangement dated September 23, 1980. Water quantity, water quality, and air quality relevant to the International Boundary were monitored in accordance with the 1991 Technical Monitoring Schedule. The monitoring data were exchanged on a quarterly basis.

This annual report is the eleventh of a series covering the period 1981-91. The report summarizes environmental conditions in the basin and discusses Committee activities for 1991. Conditions are compared to guidelines for specific parameter values that were developed by the International Joint Commission under the 1977 Reference from Canada and the United States. References are made to State, Provincial, or Federal standards or objectives where these are relevant. After examination and evaluation of the monitoring information for 1991, the Committee finds that the measured conditions meet the recommended objectives.

During 1991, monitoring continued with only minor changes in the schedules from 1990. Ash surcharging was implemented to reduce the need for building new lagoons.

In March 1991, the five-year extension of the Cooperative Monitoring Arrangement expired. Steps were taken to extend the arrangement for another five years.

Herein is the eleventh annual report of the Poplar River Bilateral Monitoring Committee.

Yours sincerely,

J.R. Knapton
J. R. Knapton
Chair, United States Section

R. A. Halliday
Chair, Canadian Section

A. Wittich
Member, United States Section

D. D. Nargang
Member, Canadian Section

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HIGHLIGHTS FOR 1991

The Poplar River Power Station completed its eighth full year of operation in 1991. The two 300-megawatt coal-fired units generated 4 534 000 gross megawatt hours of electricity with the average capacity factors for Units No. 1 and 2 recorded at 88.7% and 86.2% respectively.

Monitoring information collected in both Canada and the United States was exchanged quarterly. In general, the sampling locations, frequency of collection, and parameters met the requirements identified in the 1991 Technical Monitoring Schedules set forth in the 1990 annual report.

Regional drought conditions continued, resulting in below normal streamflow in the Poplar River basin for the fifth consecutive year. The March to October recorded flow at the International Boundary was 3 720 cubic dam^3 or 37% of the 1931 to 1990 median seasonal flow. A volume of 459 dam^3 was delivered to Montana between May 1 and May 30 to meet the apportionment recommendations of the IJC.

On January 1, 1991, Cookson Reservoir storage was only 54% of the full-supply volume. Reservoir contents reached a maximum of 26 700 dam^3 in July. 1991 reservoir levels were below ten-year median levels. The net effect of little spring runoff over the last several years has been a decrease in reservoir water quality.

The concentrations of total dissolved solids (TDS) and boron in the East Poplar River were below the long-term and short-term objectives recommended to Governments by the International Joint Commission. However, the five-year flow-weighted concentrations (FWCs) for TDS increased to 950 mg/L, only slightly below the long-term objective of 1000 mg/L TDS. The five-year boron FWCs remained well below the long-term objective of 2.5 mg/L boron. The 4.0 mg/L objective for dissolved oxygen was exceeded once. Quality control sample splits showed less than acceptable comparability between Canadian and United States laboratories for some water quality variables.

The water quality of the common discharge point from the salinity wells is better than that of the reservoir.

Suspended particulate concentrations exceeded Saskatchewan Environment and Public Safety's 24-hour standard on two occasions. However, these exceedances are believed to have been caused by field-blown dust.

An estimated 487 830 m^3 of ash and 224 200 m^3 of supply water were added to the ash lagoons in 1991. Regular inspections showed no signs of dyke misalignment or seepage. A more detailed inspection, conducted by an outside consultant, confirmed that the lagoon dykes and liners have good integrity and the ash is contained effectively.

Extensive testing of the LIFAC desulphurization process took place in the first half of the

year. Operation of the LIFAC unit, built in 1990 to help reduce sulphur dioxide emissions, is based on a limestone injection system.

1.0 INTRODUCTION

The Poplar River Bilateral Monitoring Committee was authorized for an initial period of five years by the Governments of Canada and the United States under the Poplar River Cooperative Monitoring Arrangement dated September 23, 1980. A copy of the Arrangement is attached to this report as Annex 1. On March 12, 1987, the Arrangement was extended by the Governments for four years to March 1991. The Arrangement was further extended for another five years to March 1996, following a request from the Committee in 1991. A more detailed account of the historical background of the Monitoring Arrangement is contained in the 1990 Annual Report of the Poplar River Bilateral Monitoring Committee.

The Committee is composed of representatives of the Government of the United States of America, the State of Montana, and the Government of Canada and the Province of Saskatchewan. In addition to the representatives of Governments, two ex-officio members who are local representatives of the State of Montana and Province of Saskatchewan participate in the activities of the Committee.

During 1991, the member and ex-officio members of the Committee were:

Table 1.1 1991 Membership of the Poplar River Bilateral Monitoring Committee

United States Section	Canadian Section
Mr. J. R. Knapton U.S. Geological Survey Chairman	Mr. R. A. Halliday Environment Canada Chairman
Mr. A. Wittich Governor's Office Member	Mr. D. D. Nargang Saskatchewan Environment and Public Safety Member
Mr. C. W. Tande Daniels County Commissioner Ex-Officio Member, Montana	Mr. J. R. Totton Reeve, R.M. of Hart Butte Ex-Officio Member, Saskatchewan

The monitoring programs are in response to potential impacts of a transboundary nature resulting from SaskPower's (formerly Saskatchewan Power Corporation) coal-fired thermal generating station and ancillary operations near Coronach, Saskatchewan. Monitoring is conducted in Canada and the United States at or near the International Boundary for quantity and quality of both surface and ground water and for air quality. Participants from both countries, including Federal, Provincial and State agencies, are involved in monitoring.

The Committee submits an annual report to Governments which summarizes the monitoring results, evaluates apparent trends, and compares the data to objectives or standards recommended by the International Joint Commission (IJC) to Governments, or relevant State, Provincial, or Federal standards. The Committee reports to Governments

on a calendar year basis, with the report for 1991 being the eleventh in the series. The Committee is also responsible for drawing to the attention of Governments definitive changes in monitored parameters which may require immediate attention.

A responsibility of the Committee is to review the adequacy of the monitoring programs in both countries and make recommendations to Government on the Technical Monitoring Schedules. The Schedules are updated annually for new and discontinued programs and for modifications in sampling frequencies, parameter lists, and analytical techniques of ongoing programs. The Technical Monitoring Schedules listed in the annual report (Annex 2) are given for the forthcoming year. The Committee will continue to review and propose changes to the Technical Monitoring Schedules as information requirements change.

Another responsibility of the Committee has included an ongoing quarterly exchange of data acquired through the monitoring programs. The exchange of monitoring information was initiated with the first quarter of 1981, and was an expansion of the informal quarterly information exchange program initiated between Canada and the United States in 1976. At the request of the Committee, the two governments approved replacement of the quarterly data exchange by an annual exchange effective at the start of the 1992 calendar year. Special reports dealing with aspects of monitoring and monitoring results requested by the Committee are sometimes published. Reports reviewed by the Committee during 1991 are identified in Annex 3. Exchanged data and reports are available for public viewing at the agencies of the participating governments or from Committee members.

2.0 POPLAR RIVER POWER STATION

2.1 Operations

Table 2.1 provides monthly capacity factors for each of the two units at the Poplar River Power Station. In 1991, the average capacity factors for Units No. 1 and 2 were 88.7% and 86.2%. The capacity is based on the maximum rating of 297.8 MW/h for unit No. 1 and 294 MW/h for Unit No. 2. Figure 2.1 illustrates a historical view of gross MW/h for each unit from 1981.

Table 2.1 1991 Monthly Capacity Factors, Poplar River Power Station.

	CAPACITY FACTOR (%)	
MONTH	UNIT NO. 1	UNIT NO. 2
January	100.5	90.1
February	101.0	99.6
March	95.8	99.4
April	61.1	87.7
May	83.7	34.9
June	91.3	89.0
July	73.4	75.4
August	86.7	90.7
September	94.2	93.2
October	79.5	99.7
November	97.4	76.5
December	100.7	99.5
1991 Average	88.7	86.2
1990 Average	88.1	88.4
1989 Average	93.9	93.3
1988 Average	79.6	96.2
1987 Average	92.9	75.3
1986 Average	76.8	76.3
1985 Average	89.0	87.0
1984 Average	79.0	82.0

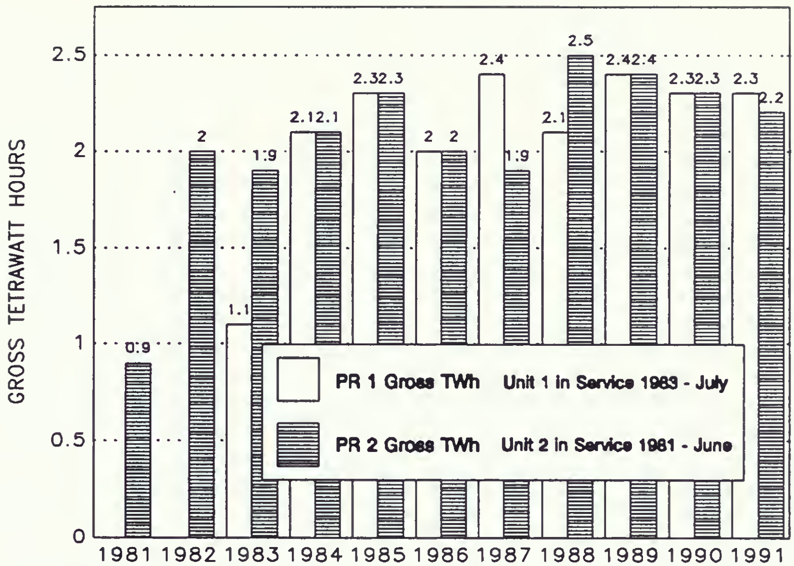

Figure 2.1 Production History 1981 - 1991, Poplar River Power Station.

Monthly coal consumption and gross MW/h production is summarized in Table 2.2. Oil consumption is also provided, but monthly values represent both Unit No. 1 and Unit No. 2 consumption. Yearly plant oil and coal usage from 1981 to 1991 are illustrated in Figure 2.2.

2.2 Construction

There was only minor construction completed during 1991. During the summer a pump pad was built in the north west corner of Ash Lagoon No. 3 North. This pump pad allows the pumps that transfer water from Ash Lagoon No. 3 to Ash Lagoon No. 2 to be raised

Table 2.2 1991 Monthly Gross MW/h and Fuel Consumption, Poplar River Power Station.

	UNIT NUMBER 1		UNIT NUMBER 2		
Month	Gross MW/h	Coal Consumption (Mg)	Gross MW/h	Coal Consumption (Mg)	PR1/PR2 Oil (m^3)
January	222 700	184 841	197 000	163 510	140
February	202 100	169 764	196 700	165 228	102
March	212 300	178 332	217 500	182 700	60
April	131 100	110 209	185 600	156 155	155
May	185 400	155 736	76 300	64 092	408
June	195 700	164 388	188 500	158 340	121
July	162 600	137 083	165 000	139 109	148
August	192 000	161 280	198 500	166 740	214
September	202 000	170 917	197 300	166 711	42
October	176 100	147 924	218 000	183 120	29
November	208 900	192 075	161 900	152 595	360
December	223 200	187 488	217 700	182 868	44
1991	2 314 100	1 960 037	2 220 000	1 881 168	1 823

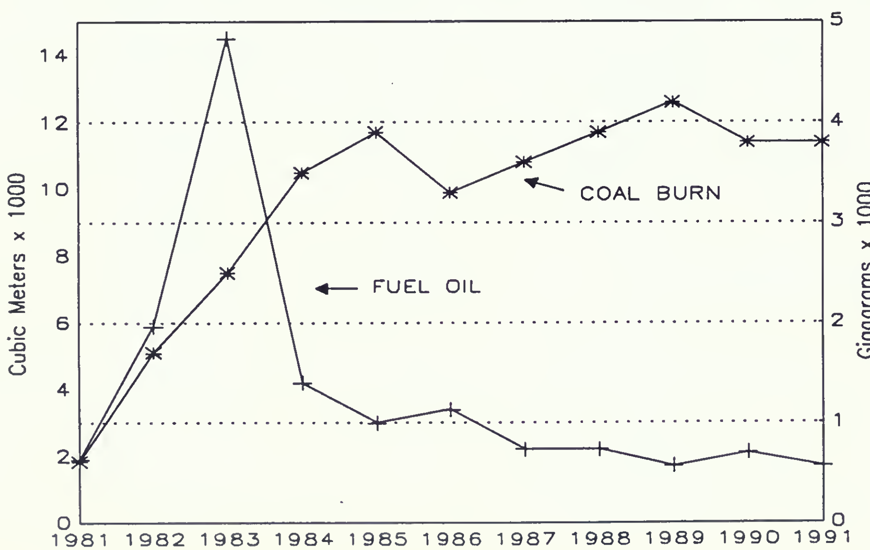

Figure 2.2 Fuel Consumption 1981 - 1991, Poplar River Power Station.

about 3 metres, this in turn allows higher operating levels for Ash Lagoon No. 3 North. The pump pad was constructed by adding material to the dyke, no portion of the dyke was excavated.

Historically, surface flow from the switch yard, located north of the Poplar River Power Station, flowed north unobstructed to Cookson Reservoir. In the last quarter of 1991, the drainage from this area was redirected south to the power station's surface water drainage system which is controlled by Scribner Dam. Advantages of this change include routine testing of water originating from the switch yard before release and more importantly, a means of containment in the case of oil leaks from a transformer.

2.3 Unusual Events

There were no reportable spills during 1991.

2.4 LIFAC

In 1989, SaskPower entered into a joint venture with Tampella Ltd. of Finland to build a demonstration unit for Tampella's LIFAC desulphurization process. The intent of the project is to allow SaskPower an opportunity to fully evaluate the technology for possible future applications while offering Tampella an opportunity to demonstrate the process to other potential customers.

The demonstration unit was added to Unit No. 1 at the Poplar River Power Station. Construction occurred during the first eight months of 1990 and the system was commissioned in September 1990. Initial testing of the LIFAC process took place from late October 1990 to the first week of December 1990.

Extensive testing of the LIFAC process took place in the first half of 1991, more specifically from February 6, 1991 to April 19, 1991 and then from June 16, 1991 to July 3, 1991. Following these periods there was very little LIFAC testing was done. There is no scheduled testing of LIFAC planned for 1992.

2.5 Scribner Dam

In July 1991, the "Release Management Procedure of Scribner Dam" was updated to include oil and grease testing. In addition to the routine testing for conductivity and pH, a visible check for oil and grease will be done and a sample will be taken for oil and grease analysis. Oil and grease analysis was added to make sure no petroleum-based products are added to the reservoir.

In 1991, there were twelve releases from Scribner Dam as compared to only three in 1990. This increase can largely be accounted for by the above average rains from April 1991 to July 1991. In the last quarter of 1991, excess water from a domestic well was directed to Scribner Dam and accounts for the releases during this time. Table 2.3 provides a summary of the testing completed during 1991 for Scribner Dam. On each occasion, the contents were released to the reservoir.

Table 2.3 Scribner Dam Testing - 1991, Poplar River Power Station.

	Date Sampled	pH (units)	Conductivity (μs/cm)	Oil & Grease [1] Visible	Oil & Grease [1] (mg/L)	Date Released
1.	Jan. 29/91	6.8	420	--	--	Jan. 29/91
2.	Feb. 05/91	7.2	370	--	--	Feb. 05/91
3.	Apr. 03/91	7.7	750	--	--	Apr. 03/91
4.	May 13/91	7.3	580	--	--	May 13/91
5.	June 05/91	7.7	590	--	--	June 05/91
6.	June 23/91	8.3	990	--	--	June 23/91
7.	June 24/91	8.1	710	--	--	June 24/91
8.	June 29/91	7.6	448	N.D.	<0.1	June 29/91
9.	July 02/91	8.0	725	N.D.	0.2	July 02/91
10.	Aug. 09/91	8.3	1230	N.D.	<0.1	Aug. 09/91
11.	Oct. 16/91	8.6	2480	N.D.	0.2	Oct. 16/91
12.	Dec. 11/91	8.7	2100	N.D.	0.2	Dec. 11/91

N.D. No visible sign.

[1] - Oil and grease visible, and oil and grease testing; started with the June 29, 1991 release.

3.0 EAST POPLAR RIVER

3.1 Streamflow

Streamflow in the Poplar River basin was below normal during 1991. The March to October recorded volume of the Poplar River at the International Boundary, an indicator of natural flow in the basin, was 3 720 cubic decameters (dam^3) or 37% of the 1931 to 1990 median seasonal flow. For the fifth consecutive year, the flow has been below normal which is indicative of the prolonged drought in the great plains. A comparison of 1991 with the 1961-90 median flow is shown in Figure 3.1.

The recorded volume for the East Poplar River at the International Boundary was 2 110 dam^3 in 1991. This volume is 61% of the median annual flow since the completion of Morrison Dam in 1975.

3.2 Apportionment

In 1976 the International Souris-Red Rivers Engineering Board, through its Poplar River Task Force, completed an investigation and made a recommendation to the governments of Canada and the United States regarding the apportionment of waters in the Poplar River basin. Although Canada and the United States have not officially adopted the Apportionment Recommendation, the Poplar River Bilateral Monitoring Committee has adhered to the recommendation in each of its annual reports. Annex 4 contains the apportionment recommendation.

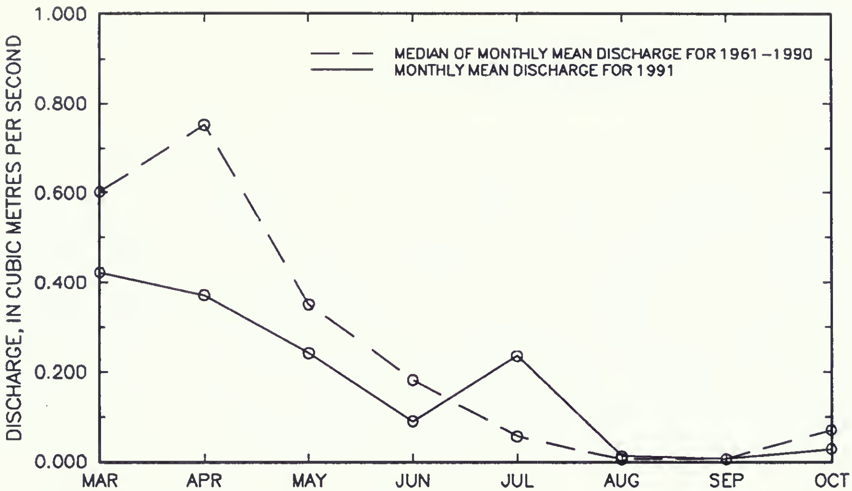

Figure 3.1 Discharge During 1991 Compared with the Median Discharge for 1961-1990 for the Poplar River at the International Boundary.

3.3 Minimum Flows

The recorded volume of the Poplar River at the International Boundary from March 1 to May 31, 1991 was 2 740 dam^3. Based on the IJC recommendations and the assumption that the recorded flow is the natural flow, the United States entitlement is a minimum discharge on the East Poplar River of 0.028 m^3/s for the period June 1, 1991 to May 31, 1992. The minimum flow for the period January 1 to May 31, 1991 had previously been determined on the basis of the Poplar River flow volume for March 1 to May 31, 1990. A hydrograph of the East Poplar River at the International Boundary and the minimum flow as recommended by the IJC are shown in Figure 3.2. All daily flows during 1991

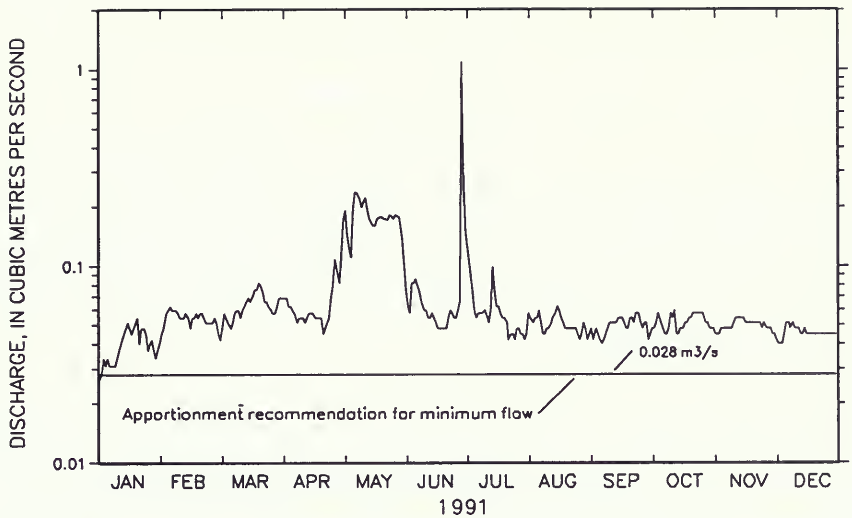

Figure 3.2 Flow Hydrograph of the East Poplar River at the International Boundary.

were above the recommended minimum with the exception of January 1. Icing as a result of extremely cold weather reduced the flow to 0.026 m^3/s on this day.

3.4 On-Demand Release

In addition to the minimum flow, the IJC apportionment recommendation entitles Montana to an on-demand release to be delivered during the 12 month period commencing June 1, 1991. Based on the runoff volume of the Middle Fork Poplar River during the March 1 to May 31, 1990 period, Montana was entitled to a release of 370 dam^3 from Cookson Reservoir. Montana requested this release be delivered between May 1 and May 30, 1991. A volume of 459 dam^3 was delivered during this period.

3.5 Water Quality

The 1981 report by the IJC to Governments recommended:

> *For the March to October period, the maximum flow-weighted concentrations should not exceed 3.5 milligrams per litre (mg/L) for boron and 1500 mg/L for TDS for any three consecutive months in the East Poplar River at the International Boundary. For the March to October period, the long-term average of flow-weighted concentrations should be 2.5 mg/L or less for boron, and 1000 mg/L or less for TDS in the East Poplar River at the International Boundary.*

For the period prior to 1982, three-month moving flow-weighted concentrations (FWC) for boron and TDS were calculated solely from monthly monitoring results. Since the beginning of 1982, the USGS has monitored conductivity daily in the East Poplar River at the International Boundary, allowing estimates of daily boron and TDS concentration to be derived from regression relationships with conductivity. Thus, three-month FWCs for the period 1982 to 1988 have been calculated from both the results of monthly monitoring and the daily concentration estimates.

The Bilateral Monitoring Committee adopted the approach that for the purpose of comparison with the proposed IJC long-term objectives, the boron and TDS data are best plotted as five-year moving FWCs which were advanced one month at a time.

Beginning in 1988, FWCs were calculated from the five year period preceding each plotted point. Prior to 1988, long-term averages were calculated from a five year period in which 2.5 years preceded and 2.5 years followed each plotted point. For

example, the FWC for December 1991 refers to the FWC of the period December 1986 to December 1991. It should be emphasized that the calculations have been based on the results of all samples collected for the three-month and five-year periods, and not restricted to samples collected during March to October.

3.5.1 Total Dissolved Solids

There is an inverse relationship between TDS and stream flow at the International Boundary station. During periods of high runoff, such as spring freshet, TDS drops as the proportion of stream flow derived ultimately from groundwater decreases. Conversely, during times of low stream flow (late summer, winter) the contribution of groundwater to stream flow is proportionally greater. Because the natural groundwater has a higher ionic strength than the surface water entering the river, the TDS of the stream increases markedly during low flow conditions.

TDS grab sample data collected by Environment Canada and the USGS in 1991 are shown in Figure 3.3. TDS ranged from 866 mg/L (March 14) to 1144 mg/L (May 16). The proposed short-term objective for TDS is 1500 mg/L. A time plot of the three-month moving FWCs for TDS is presented in Figure 3.4. No exceedences of the objective have been observed during any three month period since 1975. The three-month FWCs remained confined within a narrow range centred around a mean of approximately 900 mg/L during 1991.

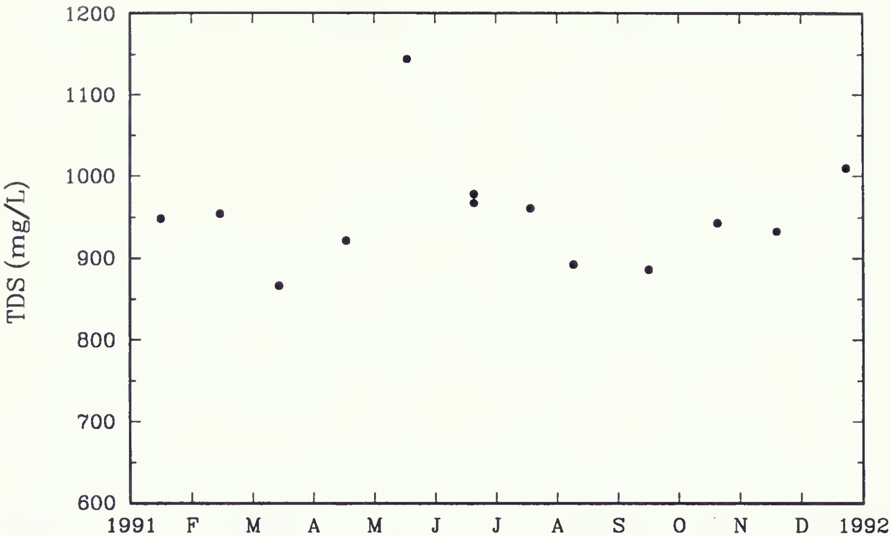

Figure 3.3 TDS Concentrations for 1991 Grab Samples from East Poplar River at the International Boundary.

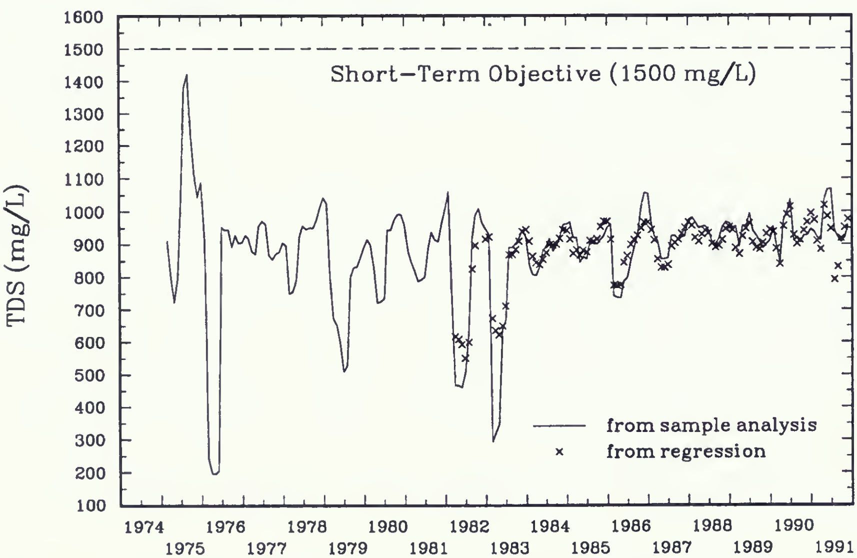

Figure 3.4 Three-Month Moving, Flow-Weighted TDS Concentration for East Poplar River at the International Boundary.

Five-year FWCs for TDS (Figure 3.5) remained below the long-term objective of 1000 mg/L. A 200 mg/L increase in the five-year FWCs which occurred in early 1988 was increased further in 1991 to approximately 950 mg/L. This corresponds to a decline in high spring flows over that period of time. A similar increase in TDS was seen during mid-1987, as a remnant of the 1982 discharge. Relatively low spring discharges have occurred since 1984. If this trend continues, it is expected that FWCs will soon approach the 1000 mg/L objective.

Using the Seasonal Kendall Tau test for trend assessment, TDS showed a statistically significant increase from 1981 to 1991 (90% confidence level). The Seasonal Kendall Sen Slope estimates the approximate TDS increase to be 2.63 mg/L/year (Figure 3.6). This positive trend could be explained by the drought conditions that occurred over the later half of the data record. The TDS increase comes from salt buildup in the reservoir as a result of water being used for cooling. High evaporation of this water (as a result of drought conditions) causes salts to remain within the reservoir. In addition, low flow conditions (when flows are derived largely from groundwater sources) likely increase TDS concentrations and yields a positive TDS trend in the data.

The relationship between TDS and conductivity generated from data collected from 1975 to 1991 is as follows:

$$\textbf{TDS} = (\mathbf{0.640 \times \text{specific conductance}}) + \mathbf{12.149}$$

$$(R^2=0.87,\ n=422)$$

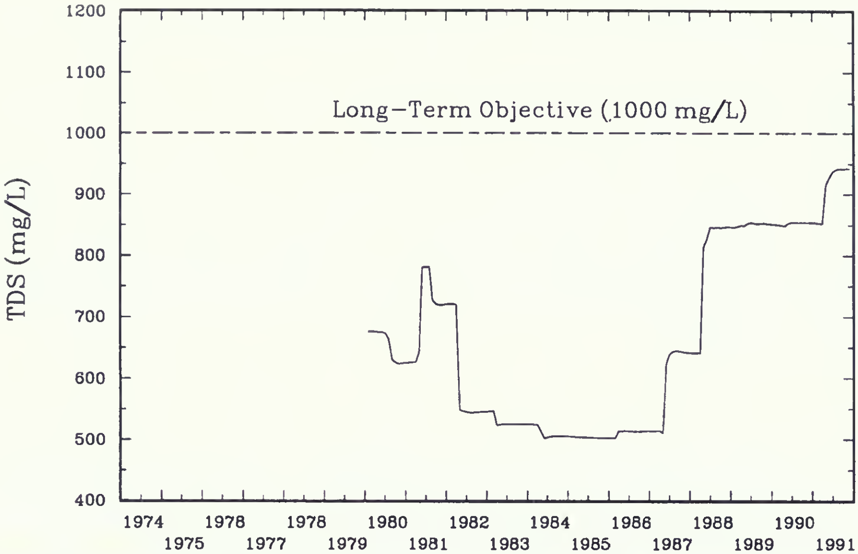

Figure 3.5 Five-Year Moving, Flow-Weighted TDS Concentration for East Poplar River at the International Boundary.

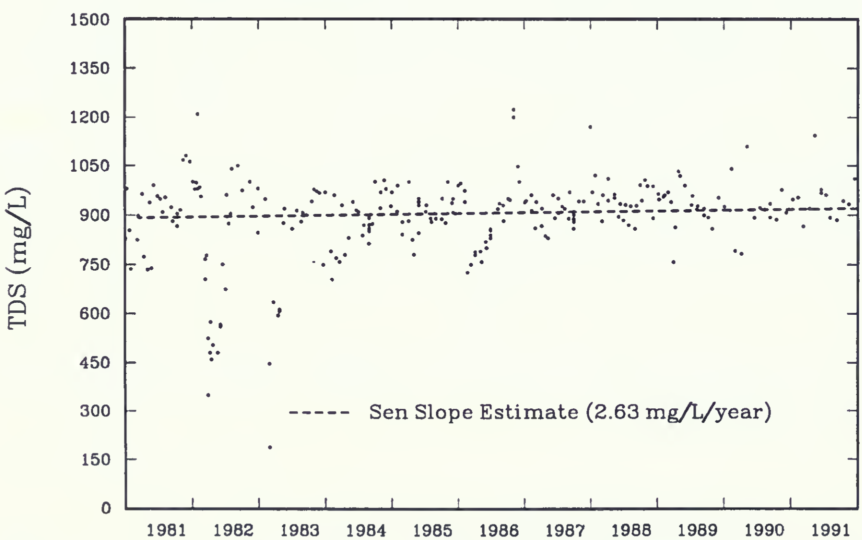

Figure 3.6 Sen Slope Estimate for TDS at East Poplar River at the International Boundary.

3.5.2 Boron

During 1991, boron concentrations in the East Poplar River at the International Boundary varied from 1.63 mg/L (Nov. 14) to 2.1 mg/L (Jun. 18 and Dec. 18) (Figure 3.7).

Three-month boron FWCs for the period of record are shown in Figure 3.8. The short term objective of 3.5 mg/L boron was not exceeded for the period 1975-1991. The similarity in shape between the TDS and boron plots (Figures 3.4 and 3.8) is a strong indication of the significance of discharge in FWC functions.

The five-year boron FWCs, displayed in Figure 3.9, remained well below the long-term objective of 2.5 mg/L boron. From mid-1988 to the end of 1990, there was a slight increase in the five-year boron FWC. In first quarter of 1991 the five-year boron FWC increased to 1.9 mg/L. As was the case with TDS, the five-year calculations for boron were significantly influenced by the relatively large discharge during 1985 and the low discharges in 1986.

The relationship between boron and conductivity at the East Poplar River sampling location during the period 1975-1991 is described by the equation:

$$\textbf{boron} = (0.00148 \times \textbf{specific conductance}) - 0.256$$
$$(R^2=0.70,\ n=422)$$

As shown in Figure 3.10, boron levels undergo a statistically significant increase from

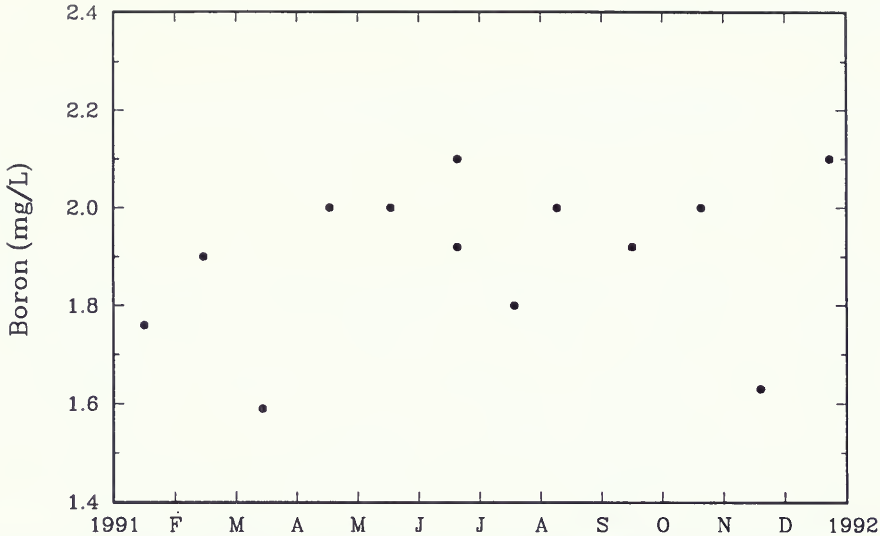

Figure 3.7 Boron Concentrations for 1991 Grab Samples from East Poplar River at the International Boundary.

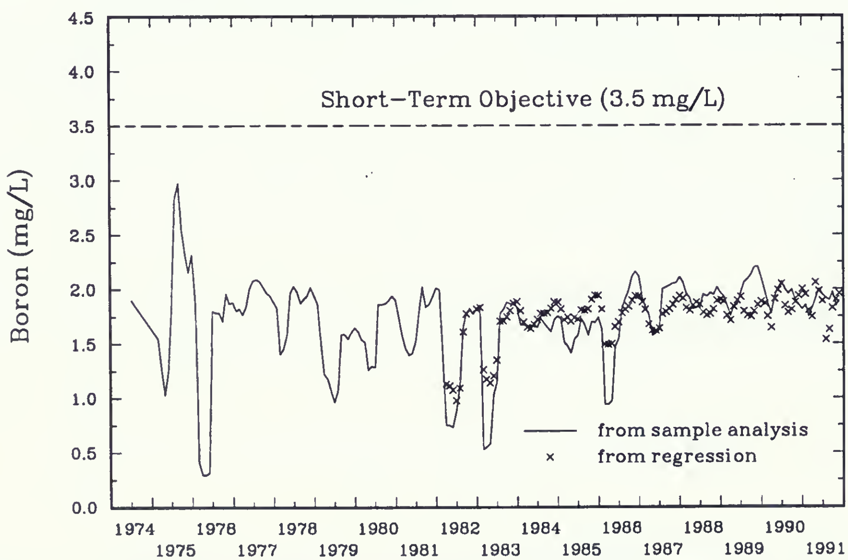

Figure 3.8 Three-Month Moving, Flow-Weighted Boron Concentration for East Poplar River at the International Boundary.

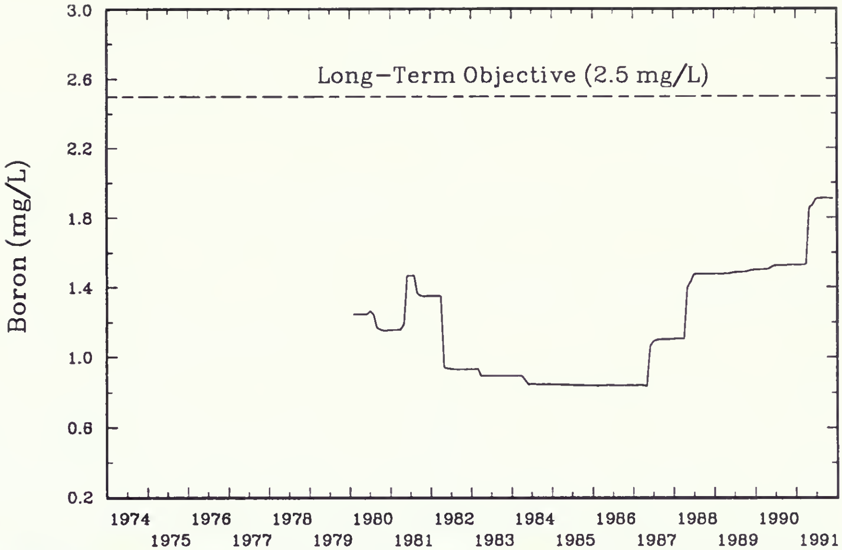

Figure 3.9 Five-Year Moving, Flow Weighted Boron Concentration for East Poplar River at the International Boundary.

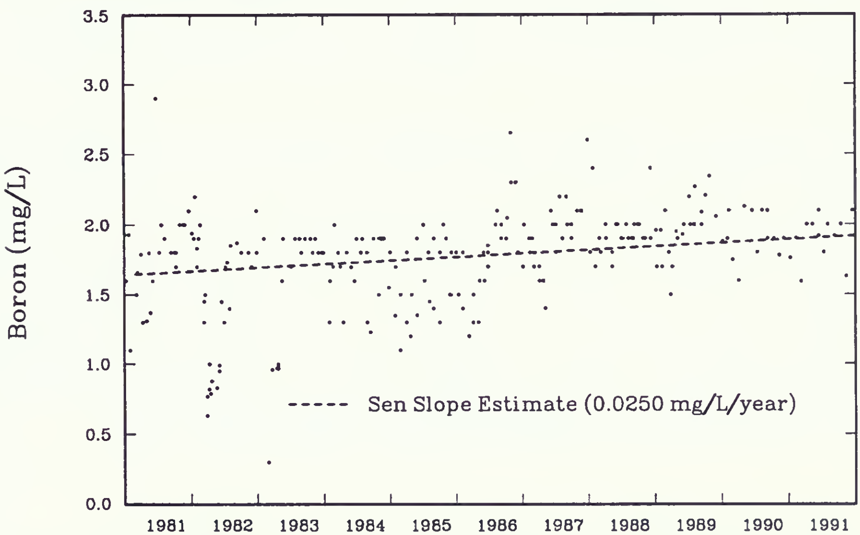

Figure 3.10 Sen Slope Estimate for Boron at East Poplar River at the International Boundary.

1981 to 1991 (90% confidence level). The boron increase, as calculated by the Seasonal Kendall Sen Slope Estimate, is approximately 0.0250 mg/L/year. As with TDS, this trend may be explained by the drought conditions in addition to consumptive use of water for cooling and natural evaporation from Cookson Reservoir.

3.5.3 Other Water Quality Variables

Table 3.1 contains the multipurpose water quality objectives for the East Poplar River at the International Boundary, recommended by the International Poplar River Water Quality Board to the IJC. One exceedence of the multipurpose objectives occurred in 1991. The 4.0 mg/L objective for dissolved oxygen was exceeded for an Environment Canada sample collected on January 15, 1991 (2.5 mg/L). It is believed that the extensive ice cover coupled with low flow conditions drastically inhibited the aeration process.

Environment Canada monitored the East Poplar River for phenoxyacid herbicides and organochlorine compounds during 1991. Trace concentrations of 2,4-D (in two of nine samples), gamma-BHC (in one of nine samples), alpha-BHC (in three of nine samples), and Dicamba (in one of nine samples) were recorded. The presence of these compounds in prairie surface waters is well documented (Integrated Environments Ltd., 1991). All other organic compounds monitored were below analytical detection limits.

Table 3.1 Recommended Water Quality Objectives and Excursions, 1991 Sampling Program, East Poplar River at the International Boundary (units in mg/L except as otherwise noted).

Parameter	Objective	No. of Samples		Excursions
		USA	Canada	
Objectives recommended by IJC to Governments				
Boron-total	3.5/2.5 (1)	8	9	Nil
Total Dissolved Solids	1500/1000 (1)	8	9	Nil
Objectives recommended by Poplar River Board to IJC				
Aluminum-dissolved	0.1	4	9	Nil
Ammonia un-ionized (as N)	0.2	8	9	Nil
Cadmium-total	0.0012	1	9	Nil
Chromium-total	0.05	2	9	Nil
Copper-dissolved	0.005	2	--	Nil
Copper-total	1.0	3	9	Nil
Fluoride-dissolved	1.5	8	9	Nil
Lead-total	0.03	3	9	Nil
Mercury-dissolved	0.0002	--	--	Nil
Mercury-whole fish (mg Hg/Kg)	0.5	--	78	Nil
Nitrate (as N)	10.0	8	9	Nil
Oxygen-dissolved	4.0/5.0 (2)	8	7	1
Sodium adsorption ratio	10.0	8	9	Nil
Sulphate-dissolved	800.0	8	9	Nil
Zinc-total	0.03	2	9	Nil
Water Temperature (Celsius)	30.0 (3)	8	7	Nil
pH (pH Units)	6.5 (4)	8	9	Nil
Coliform-fecal (no. per 100 mL)	2,000	--	9	Nil
Coliform-total (no. per 100 mL)	20,000	--	9	Nil

1. Five-year average of flow-weighted concentrations (March to October) should be <2.5 boron and <1,000 TDS. Three-month average of flow-weighted concentrations should be <3.5 boron and <1,500 TDS.
2. 5.0 (minimum April 10 to May 15), 4.0 (minimum remainder of year).
3. Natural temperature (April 10 to May 15), <30 degrees Celsius (remainder of year).
4. Less than 0.5 pH units above natural, minimum pH = 6.5.

3.6 Quality Control

3.6.1 Streamflow

To test the quality of streamflow calculations made by the United States Geological Survey and Environment Canada, similar measurements were made on the East Poplar at the International Boundary on May 30, 1991, by personnel from both agencies. The discharges, as shown in Table 3.2, are within measurement error.

Table 3.2 Streamflow Measurement Results for May 30, 1991.

Agency	Time (CST)	Width (m)	Mean Area (m^2)	Velocity (m/s)	Gauge Height (m)	Discharge (m^3/s)
EC	11:00	6.00	0.707	0.245	1.692	0.173
USGS	9:05	6.70	0.771	0.223	1.689	0.172

Notes:

1. Measurement section is the GEOWEB measuring section.
2. USGS values have been converted from Imperial units.

3.6.2 Water Quality

Quality control sampling was carried out for water quality at the East Poplar River at the International Boundary on June 18, 1991. Participating agencies included the United States Geological Survey, Environment Canada, Saskatchewan Environment and Public

Safety and SaskPower.

Sets of triplicate samples were split from USGS sampling churns and submitted to the respective agency laboratories for analyses. Field procedures were identical to those used since 1986.

Most parameters showed good reproducibility. Results for total Kjeldahl nitrogen, dissolved iron and total molybdenum are not comparable. For total phosphorus, TDS and total chromium, one set of results is noticeably high compared to the other reported sets. Similarly, one of the reported data sets is low for silica and dissolved aluminum. The results reported by one agency for magnesium showed unacceptable variability. The USGS and Saskatchewan Environment and Public Safety's relatively high detection limits for nitrate/nitrite make it difficult to evaluate the results for these parameters.

Environment Canada has completed a detailed evaluation of all of the available data from past quality control exercises.

4.0 SUPPLEMENTARY WATER SUPPLY (OLD COAL MINE DEWATERING)

4.1 Operations

Since January 1, 1990, SaskPower has been operating the old Prairie Coal mine dewatering network for the purpose of using groundwater to supplement surface flows into Cookson Reservoir. Since taking over the network, SaskPower has undertaken a significant amount of work in the area. This work includes: repair, closing or abandonment of existing wells, accurate quantification of pumping rates, replacement of damaged piezometers, a hydrogeological evaluation of the East Poplar River basin and a numerical model.

In 1991, a total of 21 wells were in operating status, 5 were closed and 20 were abandoned. The wells that have been closed can still be made available for future use if the need arises. Wells that were on private land, but were scheduled for abandonment, were initially offered to the landowner for their private use. Two of these wells were taken over by the landowner and the remainder were abandoned.

4.2 Pumpage Volumes

A summary of monthly pumpages is shown in Table 4.1

Table 4.1 Supplementary Supply Monthly Pumpages.

MONTH	PUMPAGE (dam^3)	PUMPAGE (acre/feet)
January	500	405
February	449	364
March	517	419
April	512	415
May	530	430
June	528	428
July	248	201
August	212	172
September	505	410
October	527	427
November	492	399
December	494	400
TOTAL	5514	4472

4.3 Groundwater Levels

4.3.1 Saskatchewan

Figure 4.1 illustrates the drawdowns resulting from pumping for the supplementary supply. It is interesting to note that there have been minor increases in drawdown in the southern part of Township 1, Range 27, West of the Second Meridian, which is immediately along the International Boundary. Currently the 1-metre drawdown is interpreted as being

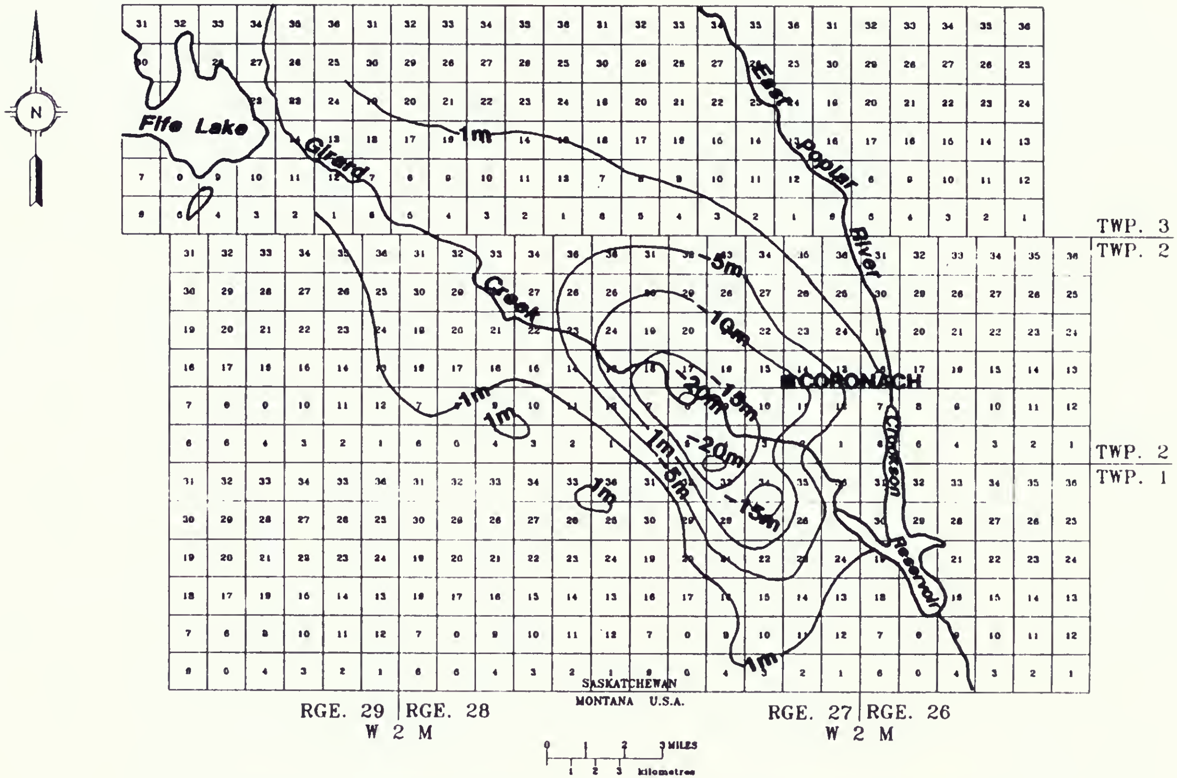

Figure 4.1 Cone of Depression in the Hart Coal Seam from Dewatering Activities as of December 1991. (Contour intervals in metres).

approximately one kilometre from the boundary. However, the majority of the expansion of the cone of depression has been to the northwest in the area of Fife Lake. Typically water levels have dropped 0.1 m to 0.3 m. Given the dry conditions in the area and the small magnitude of drawdowns, it is difficult to isolate man induced changes from natural changes.

The groundwater investigation and modelling undertaken by SaskPower have been completed. As the results of the report are being reviewed by Sask Water (formerly Saskatchewan Water Corporation), it would be premature to discuss the findings of the report.

4.3.2 Montana

Hydrographs reflecting water level measurements for selected wells in the Hart coal seam are presented in Figure 4.2. These wells continue to show trends of decline in water levels although these trends have levelled-off in 1991.

Water levels for wells 2, 8, 9, 11, and 21 continue to show no trends in water level change.

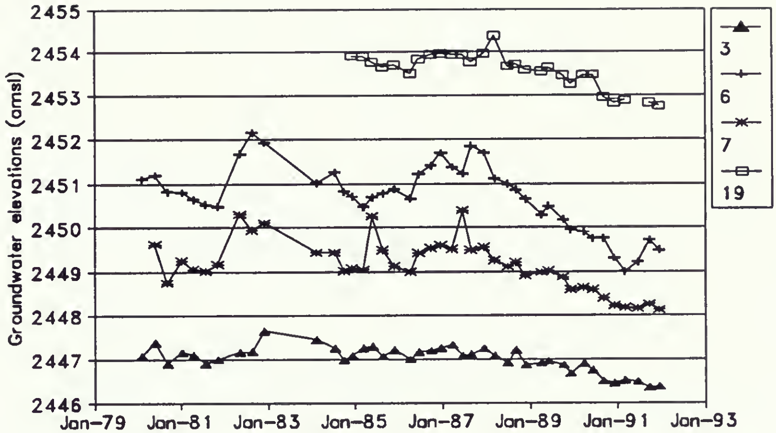

Figure 4.2 Hydrographs for Selected Wells, 1979 to 1991.

4.4 Groundwater Quality

4.4.1 Saskatchewan

The water quality from the discharge points has been consistent with no trends indicated. A summary of the more frequently tested parameters during 1991 is provided in Table 4.2. Included in this table are the average and standard deviation of the results from January 1990 to December 1991. TDS and boron results for several discharge points are illustrated in Figures 4.2 and 4.3 for 1990 and 1991 to show the consistent results of the pumpwell analysis.

Table 4.2 Poplar River Power Station, Supplementary Water Supply Project to Cookson Reservoir Discharge Pipe Average Analysis - 1991.

		Summary of 1990 and 1991 Data		
	1991 Average	Average	Standard Deviation	Girard Creek Location "C3" 1991 Average
pH (units)	7.4	7.6	0.4	7.8
Conductivity (µs/cm)	1 385	1 384	202	1220
Total Dissolved Solids	905	894	132	804
Total Suspended Solids	2.4	4.2	7.0	17.2
Boron	1.21	1.22	0.27	1.17
Sodium	177	178	34	158
Cyanide	<2	<2	0	<2
Iron	1.3	1.2	0.7	0.7
Manganese	0.22	0.23	0.11	0.15
Mercury	<0.1	<0.10	0	<0.1
- All units mg/L unless otherwise noted.				

Included in Figures 4.3 and 4.4 are the results from Girard Creek Location "C". This location is directly downstream from the majority of pumpwells and provides a good indication of water quality going to the reservoir. Water quality at "C" is much better than the reservoir quality and therefore this water has a positive influence on the reservoir water quality.

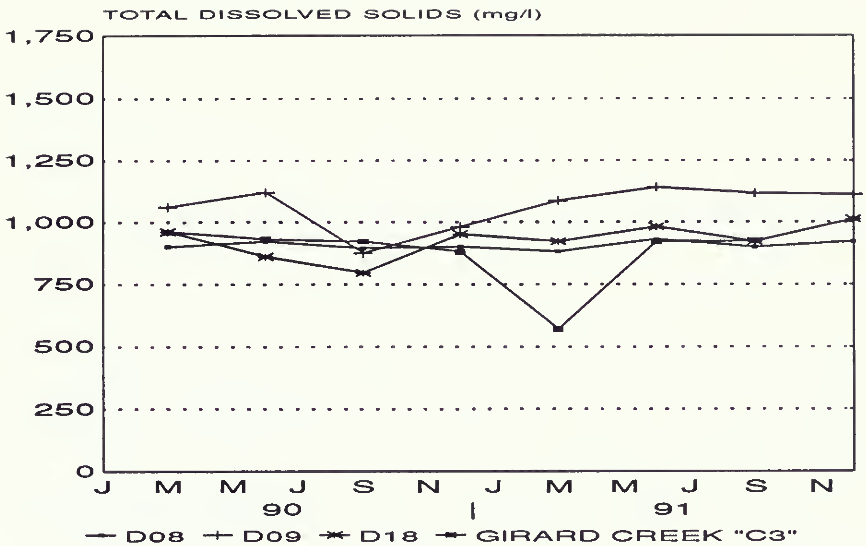

Figure 4.3 TDS for Selected Discharge Points, 1990 and 1991.

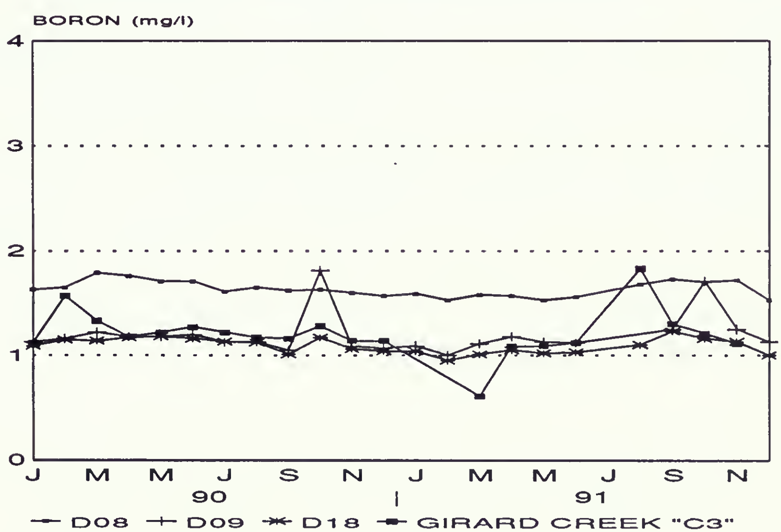

Figure 4.4 Boron for Selected Discharge Points, 1990 and 1991.

4.4.2 Montana

Sampling for water quality was performed on wells 5-11, 15, 16 and 19 in 1991. A graph of TDS versus time, for selected wells, is presented in Figure 4.5. There continues to be no significant changes in water quality.

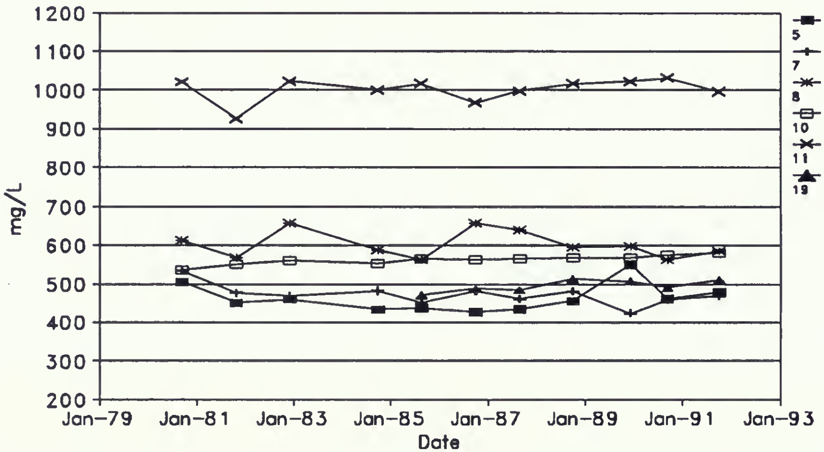

Figure 4.5 TDS for Selected Wells in the Hart Seam.

5.0 SOIL SALINITY PROJECT BELOW MORRISION DAM

5.1 Operations

Since September 1989, SaskPower has been operating a network of dewatering wells below Cookson Reservoir. The purpose of these wells is to lower the water table below the dam in an attempt to reduce salinity. At the present time the majority of the pumpage has come from four wells, with minor contributions from two additional wells.

5.2 Pumpage Volumes

Table 5.1 summarizes monthly pumpages for the salinity project. Table 5.2 summarizes the pumpage volumes for individual salinity project wells. The 1991 pumped volume of 947 dam^3 represents an increase of 181 dam^3 over 1990 volumes. This increase in total pumpage is due to an influx of 206 dam^3 from well PW 90108, which is located on the west side of the Poplar River. On the east side of the river, production from 87,102 decreased by 30 dam^3.

Table 5.1 Salinity Project, Monthly Pumpages.

MONTH	PUMPAGE (dam^3)	PUMPAGE (acre/feet)
January	103	84
February	72	58
March	86	70
April	81	66
May	54	44
June	62	50
July	66	53
August	86	70
September	78	63
October	72	58
November	86	70
December	101	82
TOTAL	947	768

Table 5.2 Individual Salinity Project Wells, Pumpage Volumes.

WELL	ANNUAL PUMPAGE (dam^3)	ANNUAL PUMPAGE (acre/feet)
PW 87102	49.0	39.6
PW 87103	233.0	188.6
PW 87104	389.0	315.0
PW 90106	15.0	12.2
PW 90107	1.0	0.8
PW 90108	260.0	210.5
* PW 87105 and PW 90109 not operating		

5.3 Groundwater Levels

5.3.1 Saskatchewan

Drawdowns for the salinity project are similar to those for the year 1990. Small changes in pumping patterns resulted in a slight decrease in drawdown on the east side of the river and a slight westward expansion of the cone of depression.

5.3.2 Montana

In 1990, two wells were installed to monitor effects of pumping the alluvial aquifers along the East Fork of Poplar River for salinity control. An attempt was made to install wells, one on each side of the East Fork of the Poplar River in the alluvium, but work on well (23) on the east side could not be completed.

Water levels in well 24 are approximately one metre below the land surface and show a decline of approximately fifteen centimetres for 1991.

5.4 Groundwater Quality

5.4.1 Saskatchewan

As a general statement, the water quality of the common discharge point from the salinity wells is better than the water quality of the reservoir. Average results from the common discharge point for 1991 are provided in Table 5.3 along with a summary of the results for 1990 and 1991. Results for boron and TDS were consistent in 1990 and 1991 (Figure 5.1).

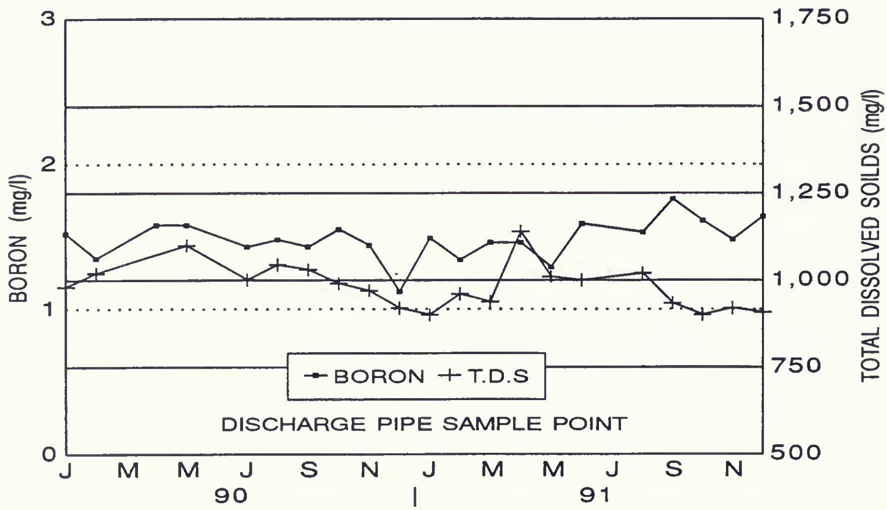

Figure 5.1 Water Quality Data from Discharge Pipe Location, South of Morrison Dam, 1990 and 1991.

Table 5.3 Poplar River Power Station, Salinity Project South of Morrison Dam Water Quality from Discharge Pipe Location - 1991.

		Summary of 1990 and 1991 Data		
	1991 Average	Average	Standard Deviation	Reservoir 1991 Average
pH (units)	7.6	7.5	0.4	8.7
Conductivity (µs/cm)	1471	1497	99	1901
Total Dissolved Solids	961	982	65	1249
Boron	1.53	1.49	0.13	2.26
Calcium	126	119	33	21
Magnesium	60	60	6.5	84.4
Sodium	148	144	4.5	330
Potassium	7.2	7.3	0.5	24.6
Arsenic (µg/L)	11.9	11.9	1.3	7.4
Aluminum	<0.010	<0.01	0	0.207
Barium	0.025	0.023	0.007	0.087
Cadmium	<0.001	<0.001	0	0.001
Iron	3.52	3.61	1.62	0.44
Manganese	0.62	0.42	1.16	0.02
Molybdenum	0.005	0.003	0.004	0.005
Strontium	1.89	1.72	0.33	0.610
Vanadium	0.003	0.003	0.004	0.007
Uranium (µg/L)	<0.1	<0.1	0	---
Mercury (µg/L)	<0.1	0.11	0.02	0.10
Sulphate	322	336	31	405

* All concentrations are mg/L unless otherwise noted.

5.4.2 Montana

Sampling of wells 23 and 24 for water quality was initiated in September of 1991. The TDS was 628 mg/L for well 24 and 2600 mg/L for well 23. Alluvial wells have TDS values that are about 600 mg/L while glacial till wells have values that are about 2600 mg/L.

6.0 COOKSON RESERVOIR

6.1 Storage

On January 1, 1991, Cookson Reservoir storage was 23 300 dam^3 or only 54% of the full-supply volume. During the year, precipitation was below normal resulting in below normal inflows. Reservoir contents reached a maximum of 26 700 dam^3 on July 6. Elevations and corresponding volumes for several dates are shown in Table 6.1. In addition to runoff, reservoir volumes were supported and maintained by ground water pumping. Wells in the abandoned west block mine site supplied 5 700 dam^3 to Girard Creek; approximately one half of this volume was estimated to have reached Cookson Reservoir. Wells in the soil salinity project area supplied 947 dam^3 directly to the reservoir.

Table 6.1 Cookson Reservoir Storage Statistics for 1991.

Date	Elevation (m)	Contents (dam^3)
January 1	749.891	23 300
July 6 (maximum)	750.528	26 700
October 29 (minimum)	749.869	23 100
December 31	749.941	23 200
Full-Supply Level	753.000	43 400

The Poplar River Power Station is dependent on water from Cookson Reservoir for cooling. Power plant operation is adversely affected when reservoir levels drop below 749 metres. The dead storage level for cooling water used in the generation process is 745 metres. The 1991 recorded levels and associated operating levels are shown in Figure 6.1. As indicated in Figure 6.1, 1991 reservoir levels are below ten-year median levels.

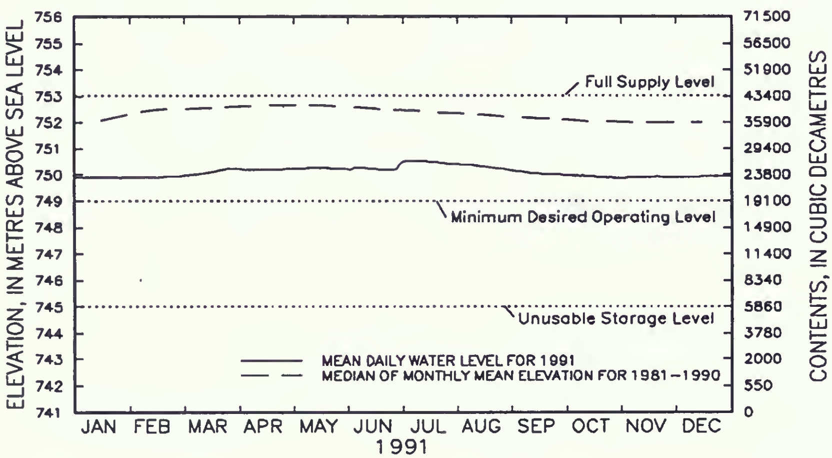

Figure 6.1 Cookson Reservoir Mean Daily Water Levels for 1991 and Median Monthly Water Levels for 1981-1990.

6.2 Water Quality

Inflow to the reservoir originates from two sources, Girard Creek and the East Poplar River North. The Girard Creek sampling point is located at the Coronach Reservoir overflow (PFRA dam). This inflow location shows strong seasonal fluctuations with no trends evident in water quality. Normally, water flows by this sample point year round as the majority of the water originates from the supplementary pumpwells described in Chapter 4.0 of this report.

The reservoir monitoring sites include the Highway No. 36 location and the Cookson Reservoir at Morrison Dam location. Strong seasonal fluctuations are evident for the upstream Highway No. 36 location. Less seasonal variation was observed for the reservoir at the Morrison Dam location due to the large volume of water involved.

The net effect of little spring runoff over the last several years has been a decrease in reservoir water quality. Figures 6.2 to 6.8 show the decreasing water volume of the reservoir and the increasing concentration of boron, sulphate, sodium, chloride, TDS, manganese, and strontium. The deterioration in water quality will continue unless there is an above average runoff in the spring of 1992.

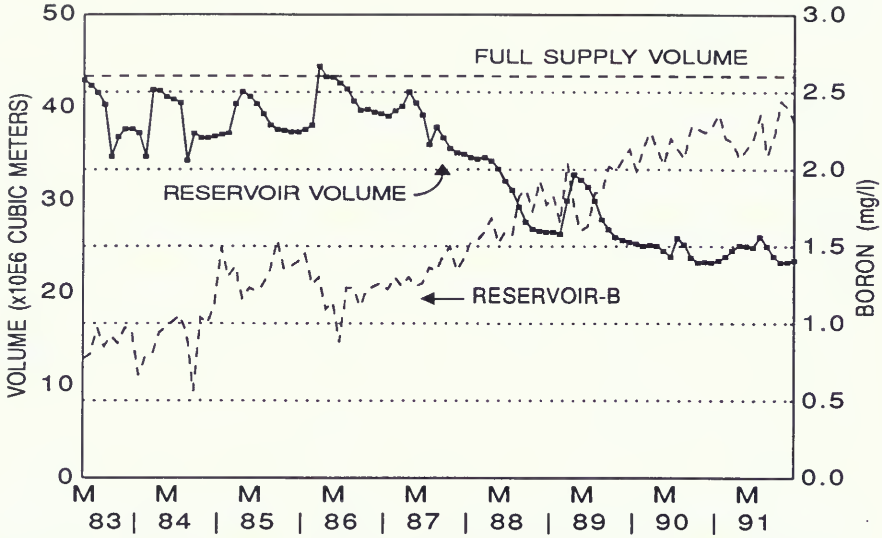

Figure 6.2 Cookson Reservoir Water Quality Data for Boron, 1983 to 1991.

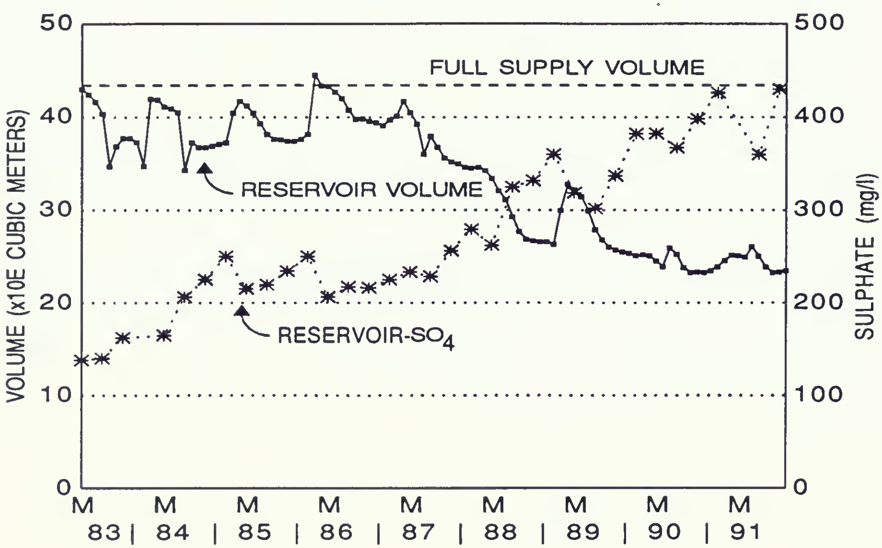

Figure 6.3 Cookson Reservoir Water Quality Data for Sulphate, 1983 to 1991.

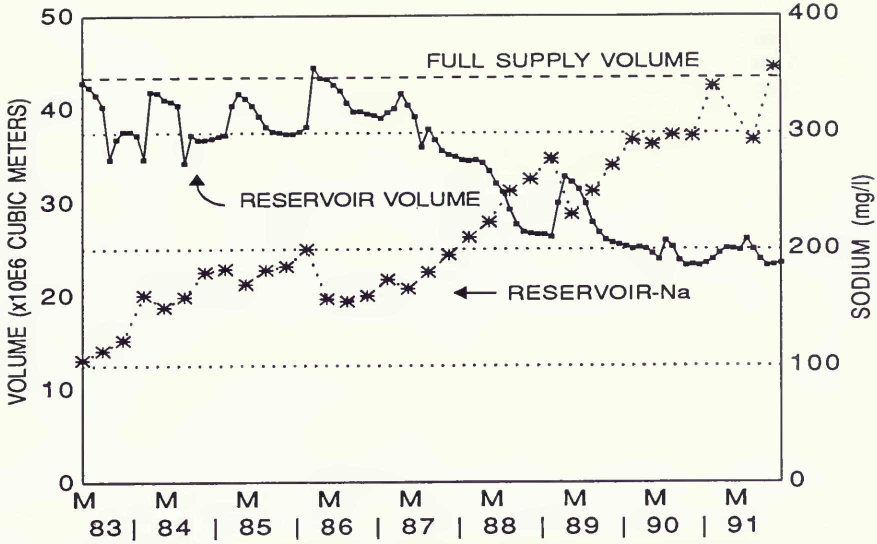

Figure 6.4 Cookson Reservoir Water Quality Data for Sodium, 1983 to 1991.

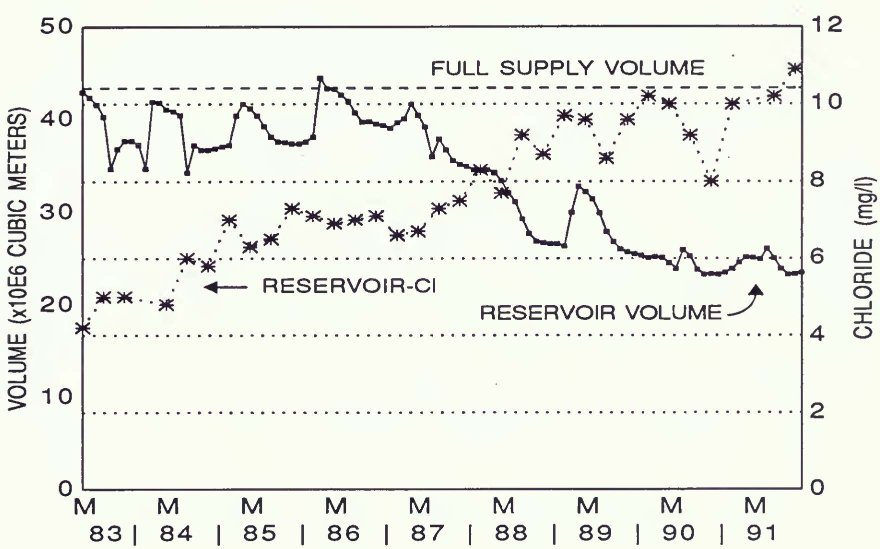

Figure 6.5 Cookson Reservoir Water Quality Data for Chloride, 1983 to 1991.

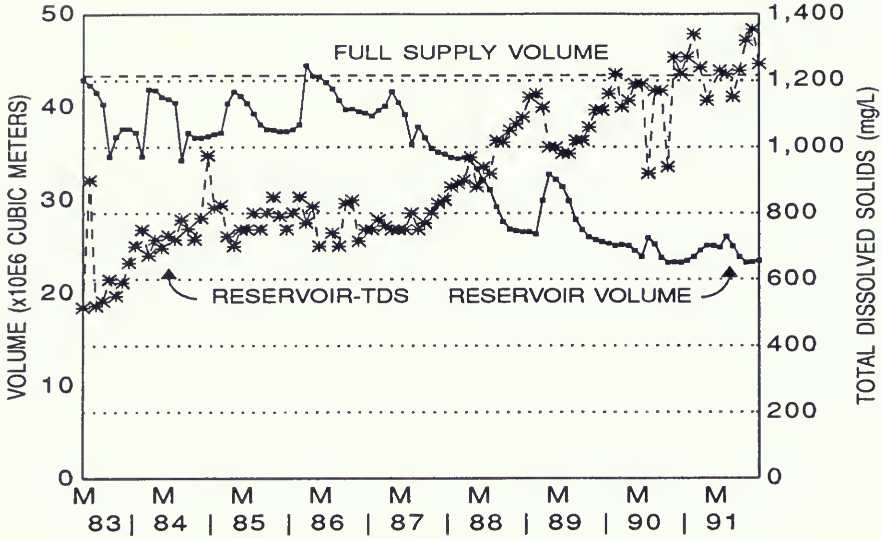

Figure 6.6 Cookson Reservoir Water Quality Data for TDS, 1983 to 1991.

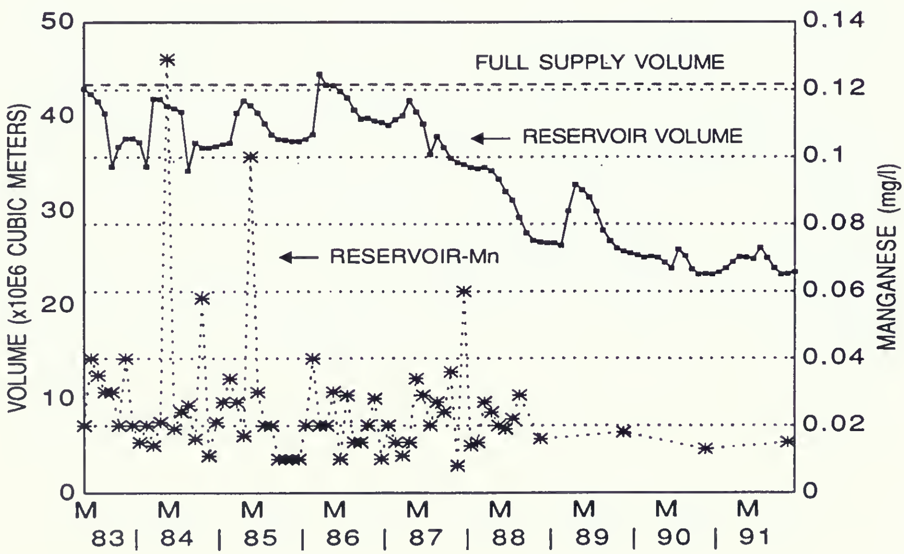

Figure 6.7 Cookson Reservoir Water Quality Data for Manganese, 1983 to 1991.

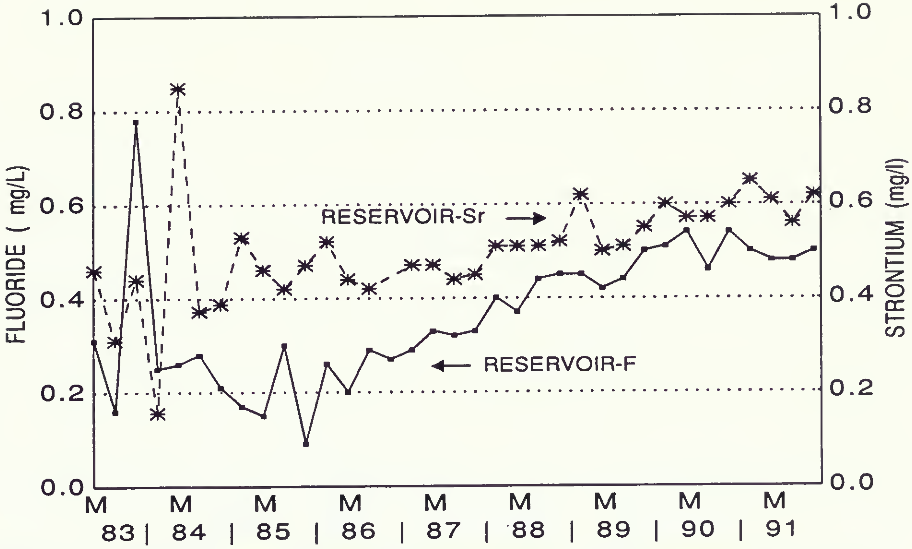

Figure 6.8 Cookson Reservoir Water Quality Data for Strontium and Fluoride, 1983 to 1991.

Reservoir outflow is monitored at the culvert immediately below the Cookson Reservoir on the East Poplar River. The primary sources of the outflow location are dam seepage and riparian leakage. Seasonal trends are noted for this location during periods of water release from the dam. Historically the water quality at this location has been poorer than that of the reservoir but is now of better quality. The quality at this location has not improved but the reservoir quality has decreased.

6.3 Mercury in Cookson Fish

Mercury levels in fish in the Cookson Reservoir have been measured on five occasions, in 1979, 1983 and 1991 by Environment Canada (Water Quality Branch 1980, Munro 1985, Shaw 1991, in prep) and in 1980 (Waite et al.) and 1984 by Saskatchewan Environment and Public Safety. Samples were collected to assess the safety of the fish in the reservoir for human consumption. These populations are confined to Cookson Reservoir and as such could only travel downstream as a result of a high runoff event. As suggested by Waite et al. (1980), based on observations from other reservoirs flooding throughout the world, high initial mercury levels in fish would be expected as a consequence of organic decay and methylation of sediment-borne metal. Elevated mercury concentrations in fish tissues would decline to pre-flooding background levels as organic matter was assimilated.

Mercury concentrations in edible tissue of two size-classes of walleye (Stizostedion vitreum) from 1979 to 1991 (Figure 6.9) followed the expected pattern. Mercury burden in edible tissue of smaller classes of walleye (25-35 cm) declined rapidly from a median concentration of 0.85 mg/Kg in 1979 to 0.29 mg/Kg in 1983. Likewise, the mercury concentration in larger fish (35-50 cm), while remaining higher than in the smaller fish, declined from 1.32 mg/Kg in 1979 to 0.42 mg/Kg in 1984. Mercury concentration of white suckers (Catastomus commersoni) from Cookson reservoir was low (median 0.25-0.29 mg/Kg Hg) and showed a slight but significant decline from 1979 to 1991 (Kruskal-Wallis 2-sample test, $p=0.61$).

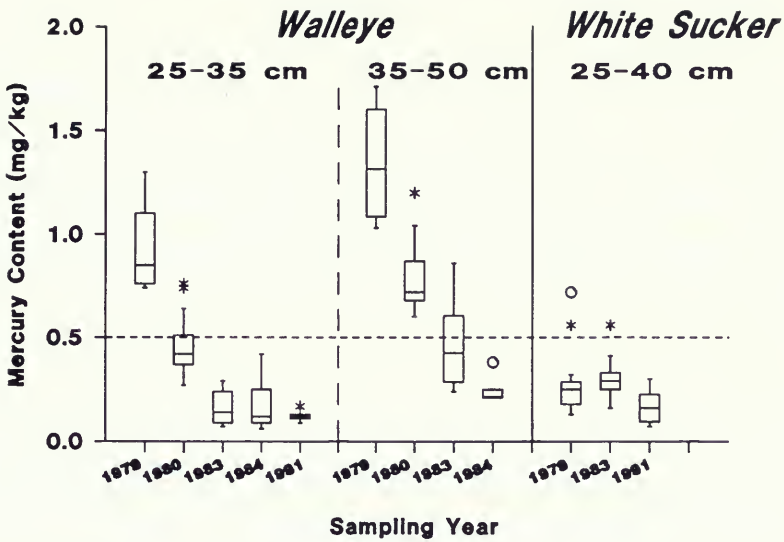

Figure 6.9 Box and Whisker Plots of Tissue Mercury Concentrations in Fish from Cookson Reservoir from 1979 to 1991. Data from Water Quality Branch (1980), Waite et al. (1980), Munro (1985) and Shaw (1991, in prep). Dashed horizontal indicates current Health and Welfare Canada consumption guideline of 0.5 mg/Kg Hg.

Munro (1985) also reported on several species of 'forage fish' from the Cookson Reservoir, such as brassy minnow (Hybognathus hankinsoni), Year-0 carp (Cyprinus carpio) and Year-0 white suckers. Mercury burden in these three fish species ranged from 0.03 to 0.25 mg/Kg. There have been no new measurements of mercury concentrations in these fish species since that study.

6.4 Morrison Dam Inspection

On September 25, 1991 a field inspection of Morrison Dam was conducted by SaskPower personnel. The entire exposed surface of the embankment and those uncovered parts of the structure were examined as well as the channel area immediately downstream of the dam. The pore pressure for the three instrumentation sections were also plotted and reviewed.

The dam and spillways were found to be working satisfactorily and generally to be in good condition. A complete check of the spillway gates is recommended in the report and this work is scheduled to be completed in 1992.

7.0 ASH LAGOONS

7.1 Operations

Operations during 1991 were similar to the last several years. Ash Lagoon No. 1 was used during winter months and Ash Lagoon No. 3 North was utilized in the summer. Ash Lagoon No. 2 continues to be used as backup when the other two lagoons are not available.

The total amount of ash that was deposited into the lagoons during 1991 is estimated at 487 830 m^3. An estimated 224 200 m^3 of supply water was added during 1991.

At the start of October 1991, all ash was directed to Ash Lagoon No. 3 North. With the colder weather experienced in the last half of October 1991, ash was redirected to Ash Lagoon No. 2, but pumping from No. 3 North continued to return as much water to the remaining lagoons as possible before freeze up. In the last week of November 1991, Ash Lagoon No. 1 was put into service and remained in service to the end of the year.

7.2 Ash Lagoon Inspections

Daily and monthly ash lagoon inspections were conducted. There was no sign of dyke misalignment or seepage.

An annual inspection to assess the condition of the ash lagoon dykes was conducted on October 03, 1991. The inspection was conducted by Edward A. Wilson, P. Eng. representing Clifton Associates Ltd., of Regina, Saskatchewan. Mr. Wilson has been responsible for several annual inspections in the past and is familiar with the site.

The conclusion of his report is that the lagoon dykes and liners have good integrity and the ash is contained effectively. The lagoon system is performing as designed. The report restates the recommendations that were made in 1990 but had not yet been complied with: (i) the installation of additional monitoring piezometers, and (ii) the dredging of ash by the No. 2 outlet structure. SaskPower plans to complete the installation of the additional monitoring piezometers in the summer of 1992. Dredging by the No. 2 discharge structure is at this time not viewed as a critical issue and has not yet been scheduled.

7.3 Dyke Stability

There are three inclinometers located along the toe of Dyke "G" designated SI 101, 102, and 103, respectively. On an annual basis, these inclinometers are measured and the results are compared to previous readings to determine possible movement over time. The measurements for this reporting period were completed June 19, 1991. There was no indication of movement in any of the inclinometers.

The 1982 Ash Lagoon Dyke Slope Stability Study, which was prepared by Clifton

Associates Limited and illustrated cross sections of the dykes, indicated a reduction in dyke stability. The water level is not exceeding the critical failure surface. A review of the hydrographs for October 1991, on piezometers associated with these cross sections does not indicate an increasing trend that would suggest the critical failure surface line will be reached.

7.4 Lagoon Water Levels

Figure 7.1 illustrates operating levels for Ash Lagoon No. 1, Ash Lagoon No. 2, Ash Lagoon No. 3 North and the polishing pond for the period 1983 to 1991. Freeboard limits were not exceeded during this reporting period for Ash Lagoon No. 2, Ash Lagoon No. 3 North and the polishing pond.

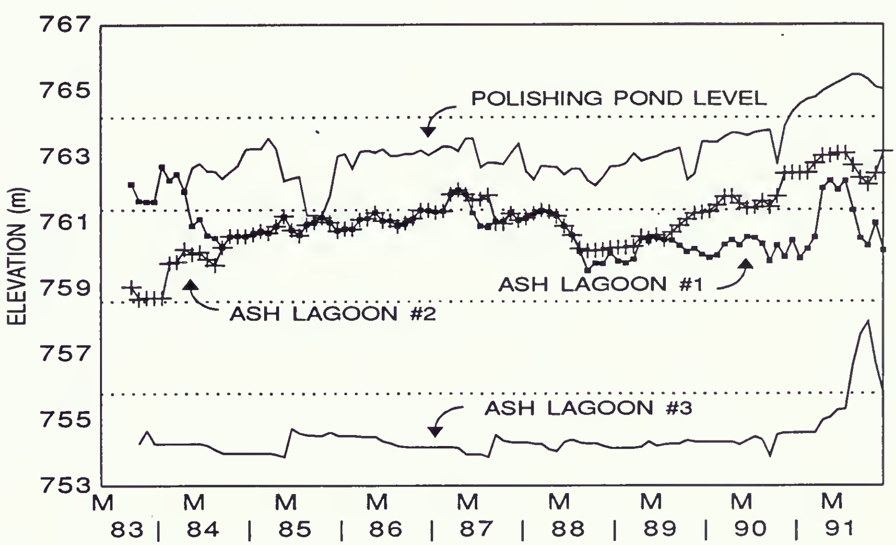

Figure 7.1 Ash Lagoon Water Levels and Polishing Pond Level, 1983 to 1991.

7.5 Lagoon Seepage Estimates

In 1990, SaskPower submitted the report entitled "Hydrogeological Evaluation - Ash Storage Lagoon" prepared by Clifton Associates Ltd., of Regina. A purpose of the report was to review the existing seepage calculations and recommend changes, if required, to the existing method or propose a new method that would increase the accuracy of the calculation.

The existing method for estimating seepage was confirmed to be acceptable but adopting an updated method was recommended. Before an updated method can be adopted, it will be necessary to obtain additional piezometer level information from within the lagoon area. Installations of new piezometers are planned for the summer of 1992. The existing calculations will be used until newer methods of completing the seepage calculations are approved. In the last quarter of 1991, comments of the report were received supporting the findings and recommendations of the report.

Results of these 1991 seepage calculations are summarized in Table 7.1 along with the results of previous calculations from 1984. The total calculated seepage was determined to be 1.267 L/s and is a large increase over the 1990 calculated value of 0.991 L/s. This increase can mostly be attributed to the growth in calculated seepage rates for Ash Lagoon No. 3 North from 0.144 L/s in 1990 to 0.332 L/s in 1991. This was expected because of the elevated operating levels for Ash Lagoon No. 3 during 1991. This was the first year that ash was directed from both units to this lagoon for the entire summer.

Table 7.1 Ash Lagoon Seepage Rates and Liner Permeabilities, Poplar River Power Station, October 1991.

		Seepage Rate		
	Liner Permeability (cm/s)	Vertical (L/s)	Horizontal (L/s)	Total (L/s)
Polishing Pond				
1984 Oct.	8.13×10^{-9}	0.055	0.128	0.183
1985 Oct.	8.70×10^{-9}	0.064	0.175	0.239
1986 Oct.	10.8×10^{-9}	0.062	0.188	0.250
1987 Oct.	14.4×10^{-9}	0.078	0.200	0.278
1988 Oct.	28.7×10^{-9}	0.087	0.226	0.313
1989 Oct.	20.6×10^{-9}	0.066	0.214	0.280
1990 Oct.	18.6×10^{-9}	0.072	0.206	0.278
1991 Oct.	27.1×10^{-9}	0.079	0.222	0.301
Ash Lagoon No. 1				
1984 Oct.	2.20×10^{-9}	0.075	0.068	0.143
1985 Oct.	3.66×10^{-9}	0.085	0.087	0.172
1986 Oct.	1.95×10^{-9}	0.083	0.070	0.153
1987 Oct.	2.36×10^{-9}	0.092	0.080	0.172
1988 Oct.	4.00×10^{-9}	0.121	0.125	0.246
1989 Oct.	2.88×10^{-9}	0.135	0.079	0.214
1990 Oct.	3.00×10^{-9}	0.160	0.076	0.236
1991 Oct.	2.16×10^{-9}	0.165	0.080	0.245
Ash Lagoon No. 2				
1984 Oct.	3.8×10^{-9}	0.116	0.114	0.230
1985 Oct.	9.22×10^{-9}	0.189	0.15	0.339
l986 Oct.	10.5×10^{-9}	0.199	0.144	0.343
1987 Oct.	11.0×10^{-9}	0.219	0.080	0.299
1988 Oct.	16.0×10^{-9}	0.236	0.081	0.317
1989 Oct.	7.8×10^{-9}	0.250	0.073	0.323
1990 Oct.	6.6×10^{-9}	0.260	0.073	0.333
1991 Oct.	9.9×10^{-9}	0.304	0.085	0.389
Ash Lagoon No. 3				
1987 Oct.	0.17×10^{-9}	0.002	0.0	0.002
1988 Oct.	*	0.022	0.0	0.022
1989 Oct.	11.8×10^{-9}	0.030	0.059	0.089
1990 Oct.	23.6×10^{-9}	0.042	0.102	0.144
1991 Oct.	18.5×10^{-9}	0.095	0.237	0.332
Total Seepage	1984 - 0.556 (L/s) 1985 - 0.750 (L/s) 1986 - 0.746 (L/s) 1987 - 0.751 (L/s)		1988 - 0.898 (L/s) 1989 - 0.906 (L/s) 1990 - 0.991 (L/s) 1991 - 1.267 (L/s)	

* Permeability could not be calculated due to negative gradients.

Total seepage rates and permeabilities of the liners are in the same order of magnitude as originally calculated by T.A. Prickitt.

7.6 Lagoon Water Quality

During the last two years, test results for many parameters have changed significantly with most sharing a common pattern of declining and then increasing. An investigation has not revealed a specific factor as to the cause of the changes but rather has indicated a series of events that may have influenced the changes. By the end of 1991, tests results were moving towards pre-1990 levels.

The graphs contained in this section illustrate the results of thirteen parameters for the polishing pond from 1983 to 1991. On many of the graphs, polishing pond volume and pH have been added for reference. Figure 7.2 illustrates polishing pond conductivity and displays the overall general condition of the polishing pond from 1983 to 1991. Historically, there has been an inverse relationship between polishing pond conductivity and polishing pond volume. An increase in polishing pond levels resulting from the addition of supply or melt-water normally results in an improvement in water quality. From 1985 to 1988, conductivity was consistent at about the 3000 µs/cm level. In mid-1988, conductivity increased as volumes within the lagoons decreased due to very high evaporation rates that year. Over the winter of 1990 and 1991, conductivity reached historic levels of 6000 µs/cm before decreasing sharply in early 1991 in response to supply water being added to the lagoon system. At the end of 1991, polishing pond

conductivity was around 3000 μs/cm.

The levels of both vanadium and chromium have been in the 0.1 to 0.4 mg/L range. During the winter of 1990/91, test results for both parameters decreased sharply below 0.1 mg/L but have since increased to near previous levels. From 1984 to 1988, a modest increasing trend was noted for molybdenum with steady values of between 3.0 and 4.0 mg/L for 1988 to 1990. From late 1990 to mid-1991, values were declining but by the end of 1991 molybdenum results had returned to pre-1990 levels.

Fluoride and sodium appear to have followed the same pattern as the other parameters during 1990 and 1991. From 1983 to 1989, fluoride results moved between the 5 and 15 mg/L levels with the occasional spike to 25 mg/L. In early 1990, results dropped sharply and remained low to late 1991 when fluoride results started to move up. From 1988, sodium results have remained stable at about 600 mg/L. In the second quarter of 1991, sodium results dropped to 446 mg/L, but like fluoride, sodium results were increasing by the end of the year. The results for chromium, sodium, vanadium, fluoride and molybdenum do not appear to be strongly influenced by polishing pond water volumes.

Sulphate results have historically moved between a wide range of 500 to 1500 mg/L. Contrary to what was observed for other parameters, there is a good relationship between sulphate results and polishing pond volumes.

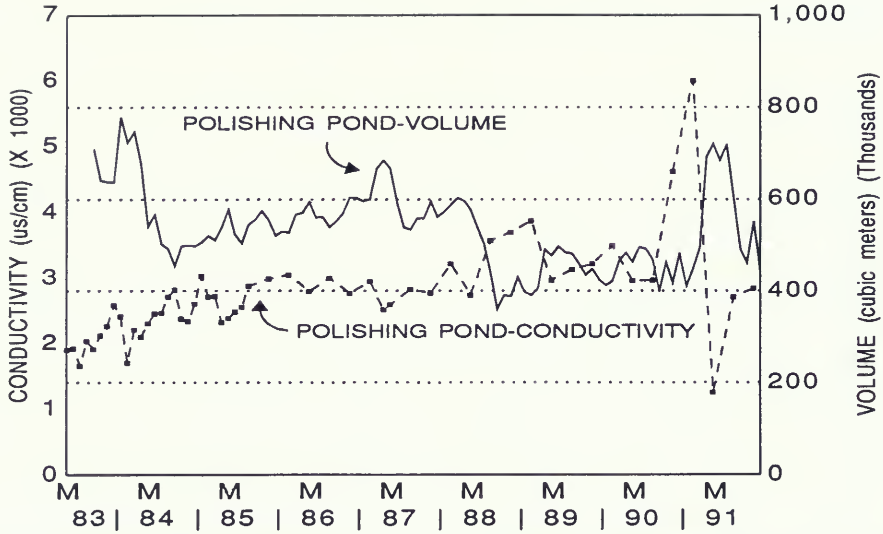

Figure 7.2 Lagoon Water Quality Data for Conductivity and Polishing Pond Volume, 1983 to 1991.

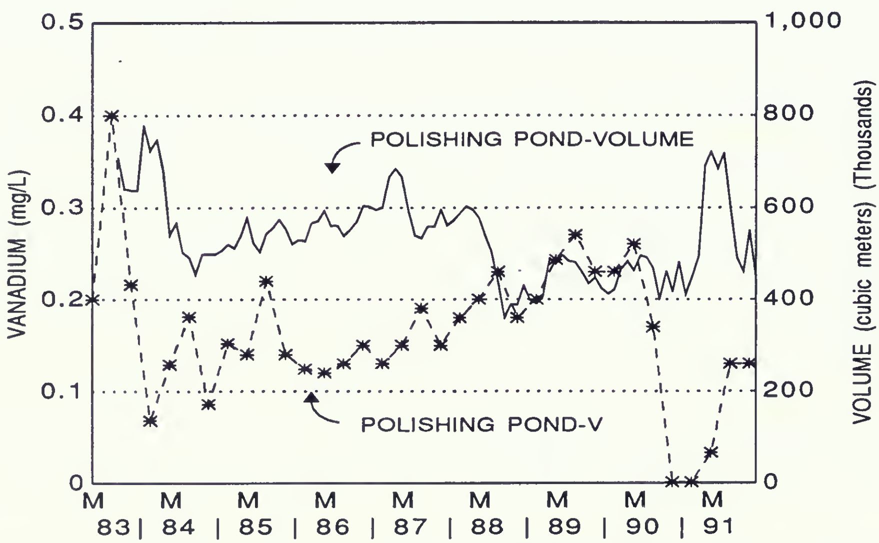

Figure 7.3 Lagoon Water Quality Data for Vanadium and Polishing Pond Volume, 1983 to 1991.

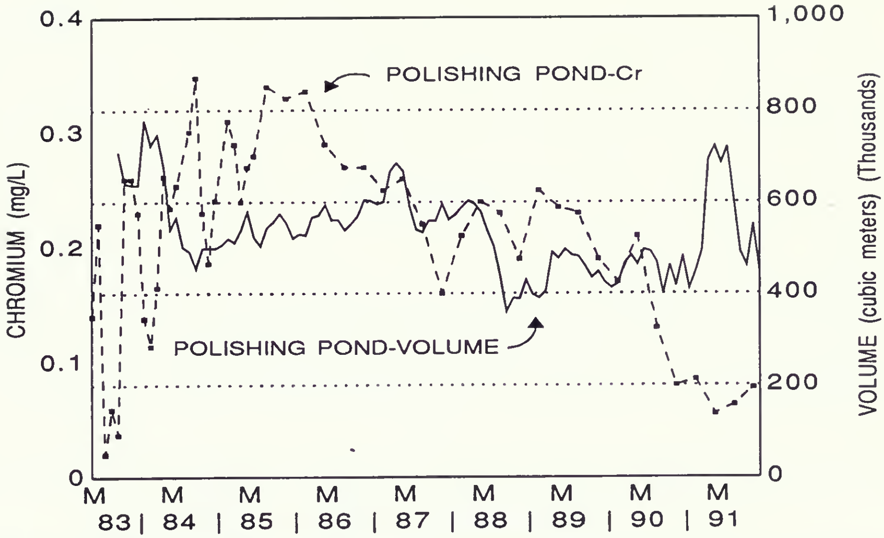

Figure 7.4 **Lagoon Water Quality Data for Chromium and Polishing Pond Volume, 1983 to 1991.**

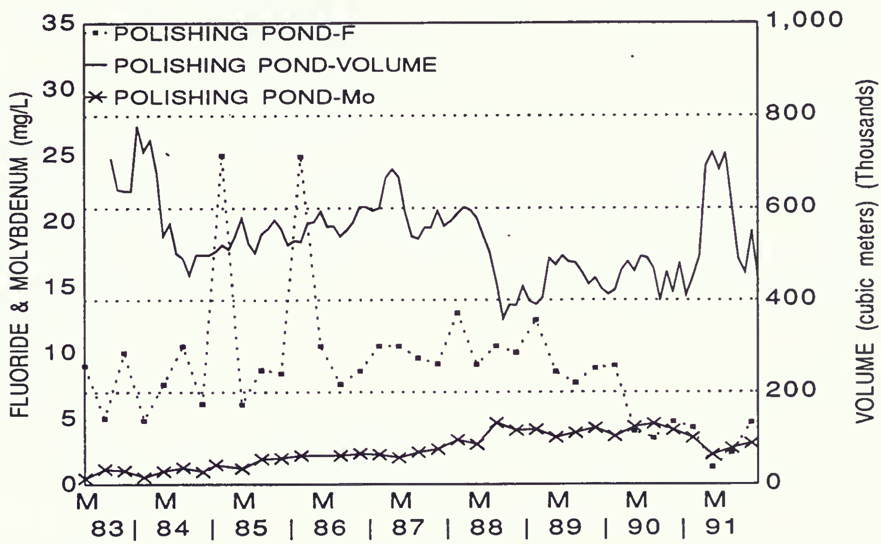

Figure 7.5 **Lagoon Water Quality Data for Fluoride, Molybdenum and Polishing Pond Volume, 1983 to 1991.**

As shown in Figure 7.7, potassium results were increasing from 1983 to 1988. A large spike of 135 mg/L was observed in August 1988, followed by steady results of about 60 mg/L to 1990. Like other test results, potassium levels dropped in early 1991 and by the end of the year had increased to previous levels.

Strontium and uranium values have shown little change from 1988 levels. Uranium levels in the lagoons have rarely exceeded detection limits (less than 0.1 µg/L). Strontium values have been decreasing from 1988 and are now consistently below 0.5 mg/L.

Figure 7.9 to Figure 7.11 illustrate calcium and magnesium results compared to changing polishing pond volume and pH results. There is an apparent softening trend of the lagoons from 1988. From 1989, magnesium levels have consistently been below 1 mg/L compared to 5 to 25 mg/L from 1983 to 1988. Calcium levels are also lower after 1988 and exhibit a much wider range of fluctuations than previously seen. In February 1991, calcium concentration was 236 mg/L but in May had dropped to 2.7 mg/L. Polishing pond volumes have likely influenced results for both calcium and magnesium. Solubilities of magnesium may be linked to elevated pH (over 10). However, high pH levels poorly explain calcium results.

One of the most interesting trends has been the sudden decrease in boron results from 1990. Historically, boron results were increasing from 1983 to 1985. This was expected as boron concentration reached solubility limits. From 1985 to 1990, boron concentrations moved within an established range of between 70 and 90 mg/L.

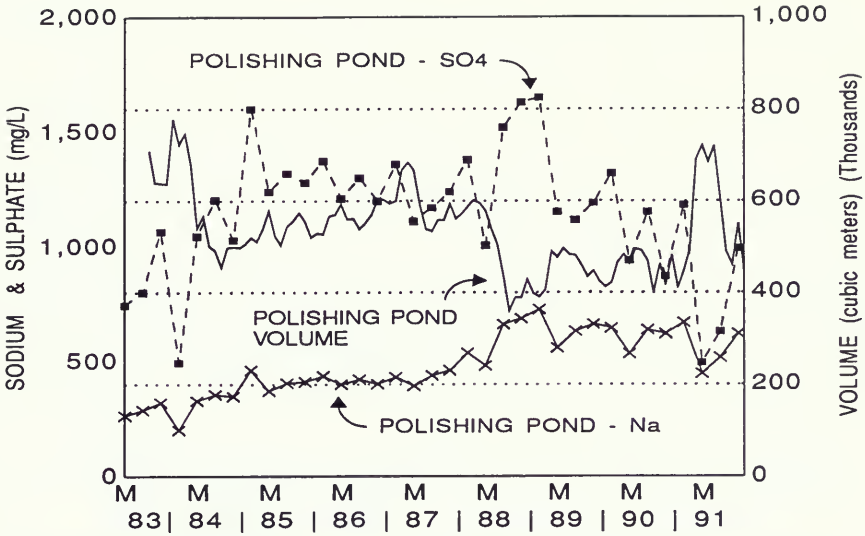

Figure 7.6 Lagoon Water Quality Data for Sodium, Sulphate and Polishing Pond Volume, 1983 to 1991.

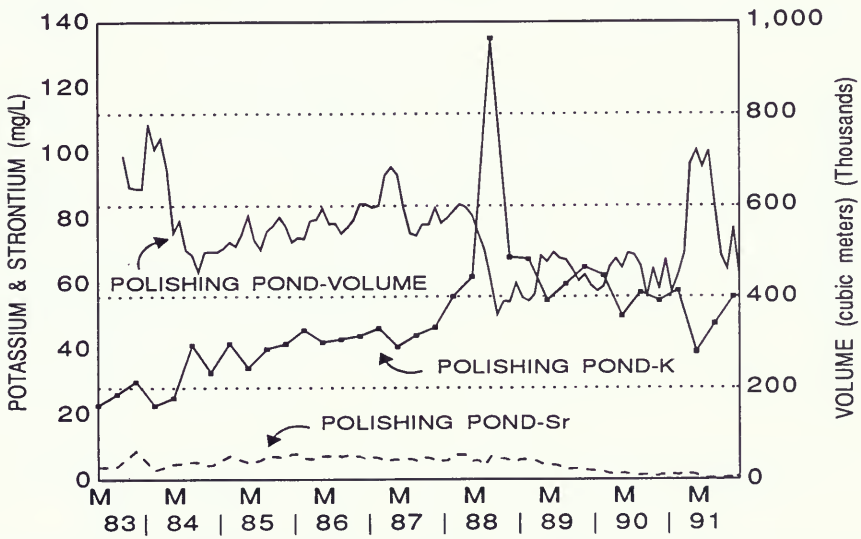

Figure 7.7 Lagoon Water Quality Data for Potassium, Strontium and Polishing Pond Volume, 1983 to 1991.

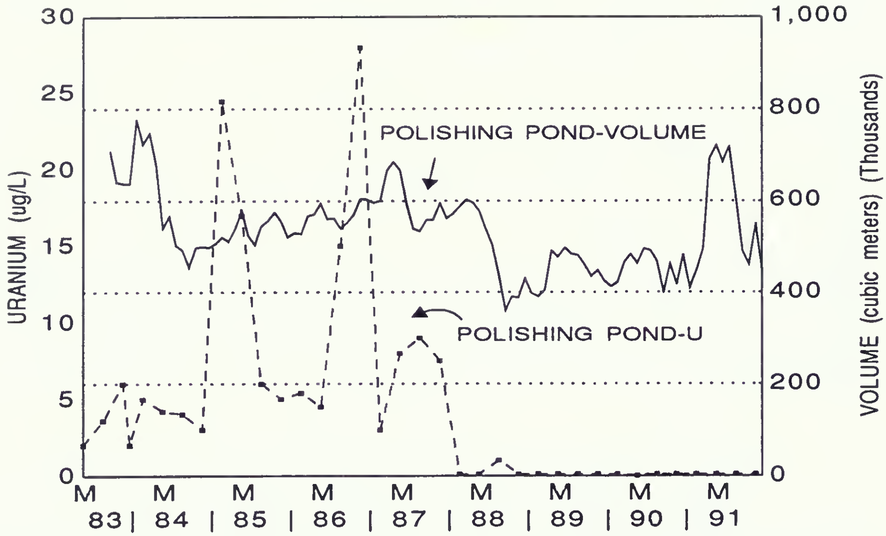

Figure 7.8 Lagoon Water Quality Data for Uranium and Polishing Pond Volume, 1983 to 1991.

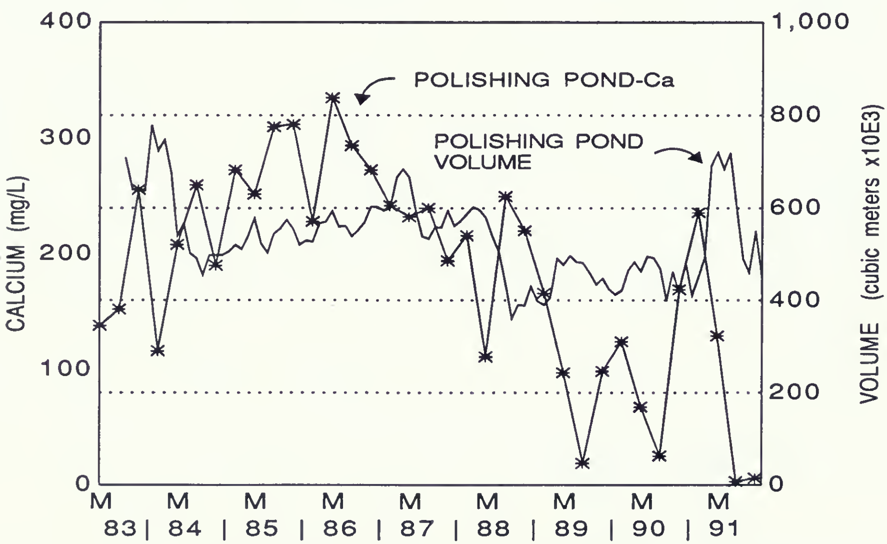

Figure 7.9 Lagoon Water Quality Data for Calcium and Polishing Pond Volume, 1983 to 1991.

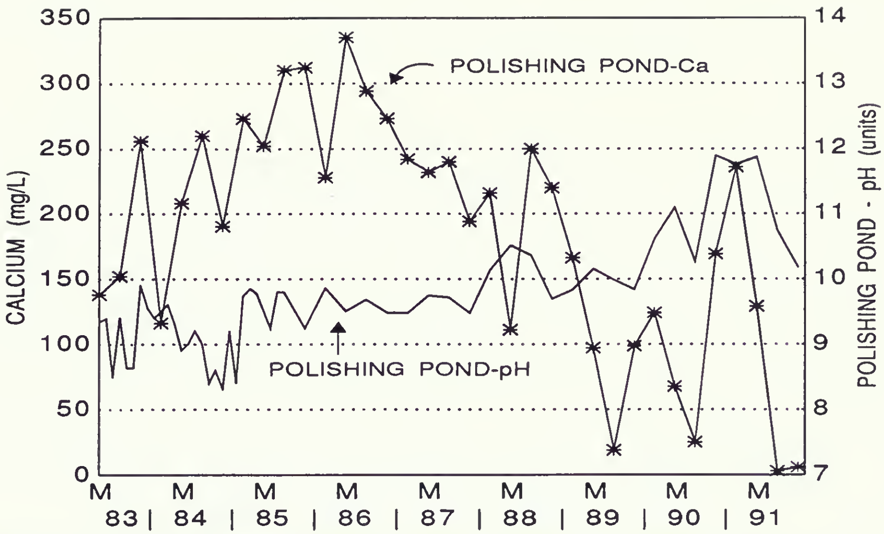

Figure 7.10 Lagoon Water Quality Data for Calcium and Polishing Pond pH, 1983 to 1991.

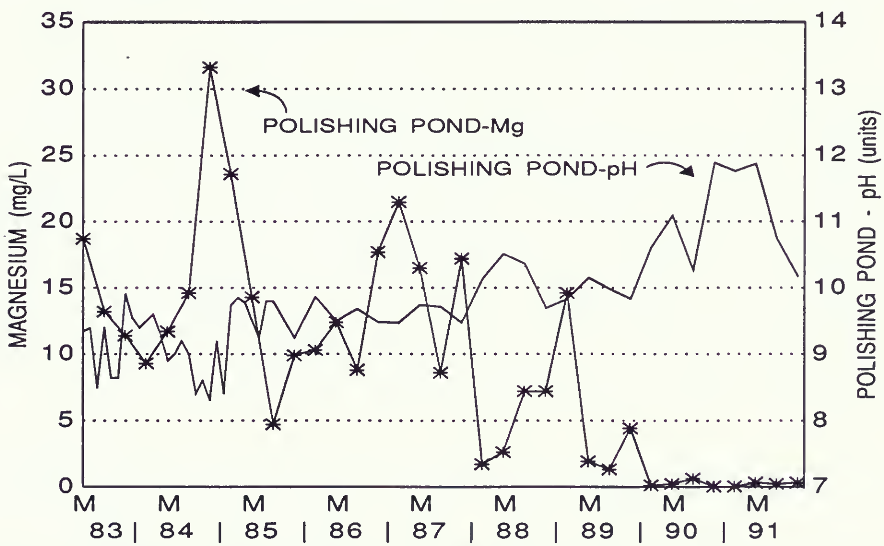

Figure 7.11 Lagoon Water Quality Data for Magnesium and Polishing Pond pH, 1983 to 1991.

Boron results moved opposite to polishing pond water levels (Figure 7.12) and by the end of 1990, boron had decreased dramatically to 20 mg/L.

Discussion presented in 1990, suggested the sudden decrease in boron during 1990 could be explained by the pH of the lagoons. With a pH greater than 10.0, boron solubility drops rapidly as shown in Figure 7.13. Information collected in 1991 still supports this suggestion. In May 1991, the polishing pond pH was over 11.8, while at the same time the boron level was near a historic low of 3.61 mg/L. By mid-1991, pH levels in the lagoon had dropped and boron levels were increasing. At the end of 1991, the pH in the polishing pond had decreased to 10.1 while the boron level was 18.1 mg/L.

One possible influence of the unusual trends seen during 1990 and 1991, is the different operating conditions seen at this time compared to other years. SaskPower has been experimenting with a limestone ($CaCO_3$) injection system called "LIFAC" to help reduce sulphur dioxide emissions. Testing of the system started in the last quarter of 1990 and lasted to the end of June 1991. It was during this time that a lot of the unusual results were seen. The chemistry of the polishing pond was known to be changing. The scaling potential of the ash water had suddenly increased and this was confirmed as the ash recirculating pumps had to be cleaned of scale regularly.

Another factor influencing lagoon water quality in 1991 was the addition in March and April of approximately 224 200 m^3 of supply water. This had a positive influence on water quality.

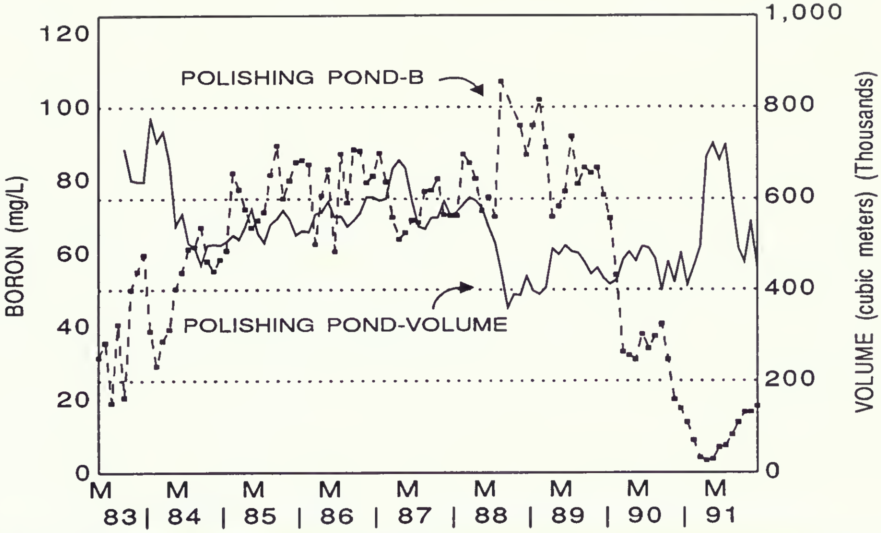

Figure 7.12 Lagoon Water Quality Data for Boron and Polishing Pond Volume, 1983 to 1991.

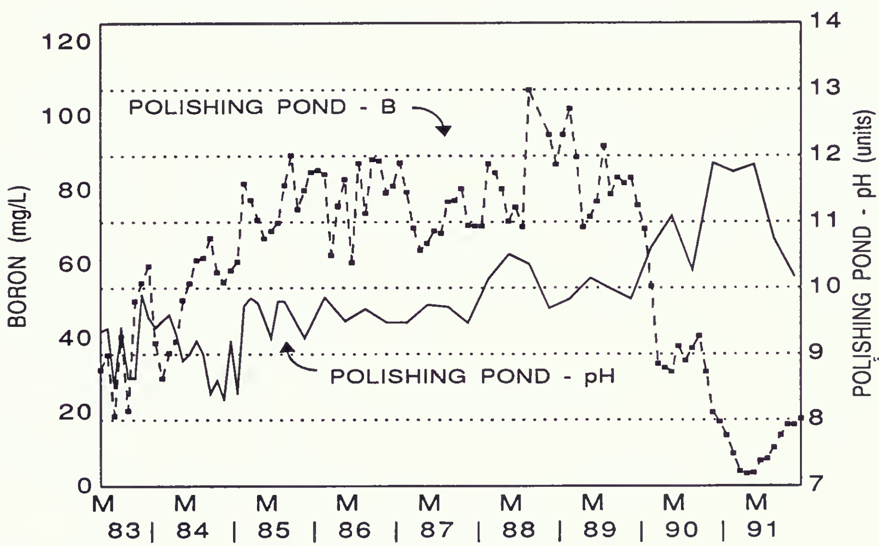

Figure 7.13 Lagoon Water Quality Data for Boron and Polishing Pond pH, 1983 to 1991.

7.7 Interceptor Trench

When Ash Lagoon No. 3 North was built, two separate interceptor trenches were also constructed along the toe side of Dykes "H" and "I". Each interceptor trench consists of two legs that drain into a manhole. The west interceptor trench's manhole (designated DG1) is at junction of Dykes "D" and "H". One leg extends south from the manhole along Dyke "D" to the end of the dyke. The other leg extends east to about the half way point along Dyke "H".

The second manhole is located at the junction of Dykes "H" and "I", (designated DG2). One leg extends west along Dyke "H" and stops before it hits the west interceptor trench. The second leg goes northeast along Dyke "I".

Draining of the interceptor trenches is expected to keep the area downstream of Ash Lagoons No. 2 and No. 3 North from becoming saturated. This is desirable because this area will eventually become Ash Lagoon No. 3 South. It will be easier and less expensive to build this lagoon if the soil is not saturated.

During the summer of 1989, electric pumps and discharge piping were installed in each manhole. The west manhole discharges in Ash Lagoon No. 2 and the east manhole into Ash Lagoon No. 3 North. Both pumps are activated by level controllers. The pumps were commissioned and put into service in December 1989.

Both pumps were in service during 1990. In the first quarter of 1990, discharge flow from the west manhole was regular and over the course of the year a noticeable decline in discharge flow was observed.

A similar pattern was observed for the east manhole but by mid-year no discharge flow was occurring. When investigated further it was determined there was no flow was coming in from the interceptor trenches feeding the east manhole. This is because groundwater levels surrounding the east manhole do not show gradients towards the east interceptor trench.

The 1990 year end pumping patterns continued throughout 1991 for both manholes. The east pumpwell rarely discharged as the west pumpwell discharged at a regular pace.

Poplar River Power Station started testing these manholes in May 1989, before pumping was started and have continued to do so on a quarterly basis. The water quality of both manholes is poor and of similar quality to that of the oxidized till piezometers. The poor water quality is because both manholes draw water from the upper horizons. Table 7.2 summarizes the data and compares information from the two manholes before and after pumping was started.

Since pumping has started, the water quality of the west manhole has declined for most tests. The increasing boron levels indicate there may be seepage activity from the lagoons towards the west interceptor trench but more analysis is needed to support this

Table 7.2 Water Quality for Lagoon Pumpwells DG1 and DG2, at Poplar River Power Station.

	DG1		DG2	
Parameter*	Before Pumping (<Dec. 1/89)	After Pumping (>Dec. 1/89)	Before Pumping (<Dec. 1/89)	After Pumping (>Dec. 1/89)
	Avg.	Avg.	Avg.	Avg.
pH (units)	7.8	7.8	8.0	7.9
Conductivity	2710	3580	4400	4462
TDS	2159	3064	3750	3846
Calcium	149	280	505	460
Magnesium	142	245	334	354
Sodium	65	100	272	275
Potassium	6.3	8.2	156	15.0
Sulphate	1287	2035	2566	2507
Chloride	35	54	100	90
Iron	<0.01	0.02	0.04	0.02
Aluminum	0.03	0.05	0.03	0.15
Fluoride	0.37	0.32	0.23	0.22
Arsenic (µg/L)	0.90	0.70	0.67	0.44
Boron	1.5	2.7	1.20	1.1
Barium	0.05	0.05	0.02	0.03
Cadmium	<0.001	<0.001	<0.001	<0.001
Cobalt	<0.001	<0.001	<0.001	<0.001
Chromium	0.003	<0.010	0.002	0.010
Copper				
Mercury (µg/L)	0.15	0.13	0.10	0.17
Manganese	0.14	0.03	0.036	0.006
Molybdenum	0.005	0.013	<0.001	0.006
Selenium	0.001	0.001	0.03	0.02
Strontium	1.36	2.85	1.81	2.2
Uranium	58	86	94	124
Vanadium	0.004	0.003	0.004	<0.001
Zinc	0.19	1.47	3.6	1.37

* All values are mg/L unless otherwise noted

conclusion. For example, seepage activity should reduce chloride levels to equal those of the ash lagoons but instead chloride levels are increasing.

7.8 Leachate Review

Historically, the leachate review has been presented through the aid of graphs to show developing trends. This report uses maps to show changes in piezometric surface, in chloride and boron for the oxidized, unoxidized and Empress layers. A total of eighteen maps are provided in Appendix 5 of this report to demonstrate these changes.

The piezometric surface for the oxidized strata shows a groundwater mound beneath the lagoons. As shown on the change in piezometric surface map, the groundwater mound extends from the east side of Ash Lagoon No. 2 where a six metre increase has been noted, to the west side of the polishing pond where levels have increased about four metres. Moving toward the reservoir, the oxidized till piezometers have shown a decreasing trend, reacting to lower reservoir levels.

The largest changes in chloride and boron levels in the oxidized till have occurred where the piezometric levels have changed the most. This would be expected because changing water levels does suggest water movement. The increasing boron results on the east and south side of Ash Lagoon No. 2 along with the decreasing chloride levels suggests a leachate influence. On the west side of the polishing pond, the boron levels have changed little but the chloride levels have increased greatly, moving opposite to

lagoon chloride levels. A waterfront may be moving through this area ahead of a leachate front.

There has been little change in boron or chloride levels for most of the oxidized till piezometers located by the reservoir. The only significant change in any of these piezometers has been C719 where chloride levels have decreased to 87 mg/L. The calculated groundwater movement in the oxidized till from the polishing pond to the reservoir is about 18 metres from 1981 to 1991. This is theoretically not yet far enough to affect this piezometer.

Like for the oxidized layer, a groundwater mound has also developed for most of the unoxidized till piezometers extending from the east side of Ash Lagoon No. 2 to the west side of the polishing pond. The size of mound does not extend as far as the oxidized layer and not all unoxidized till piezometers are affected. For example, unoxidized till piezometer C764D is located within the mound area but has historically reacted to the reservoir and is showing a decreasing level. An examination of the boron and chloride levels does not indicate any distinct trends.

The piezometric surface of the Empress gravels indicates a regional flow from west to south east below Morrison Dam. Around the lagoon area, there is a noticeable drop in piezometric head at the east side of Ash Lagoon No. 2. There is also an increasing mound at the east end of Ash Lagoon No. 3 North.

As a general observation, the closer the Empress piezometer is to the reservoir, the larger the decrease in water levels have been from 1983 to 1991. There appears to be less of a decrease beneath rather than around the lagoons. This may be due to upper horizon influences such as leachate movement or pore pressure or the water mound on the east of Ash Lagoon No. 3 North.

The boron and chloride results for the Empress layer do not indicate significant changes. The largest change in boron near the lagoons is 0.48 mg/L.

Leachate movement was also reviewed at piezometer C712B in the intra till sands on the north side of the polishing pond. Boron levels continue to show an increasing trend (Figure 7.14) and chloride results have been steady over the last several years (Figure 7.15). A slug of leachate is probably affecting this piezometer rather than a continuous plume. Comprehensive monitoring should continue at this location.

7.9 Ash Surcharging

From October 26, 1991, to November 16, 1991, the dykes on Ash Lagoon No. 1 were built up making room for future ash stacking operations. Most of the activity during this period was concentrated at the south end of the lagoon, and the south half of the east ash dyke. The ash dykes in these areas were raised about two metres.

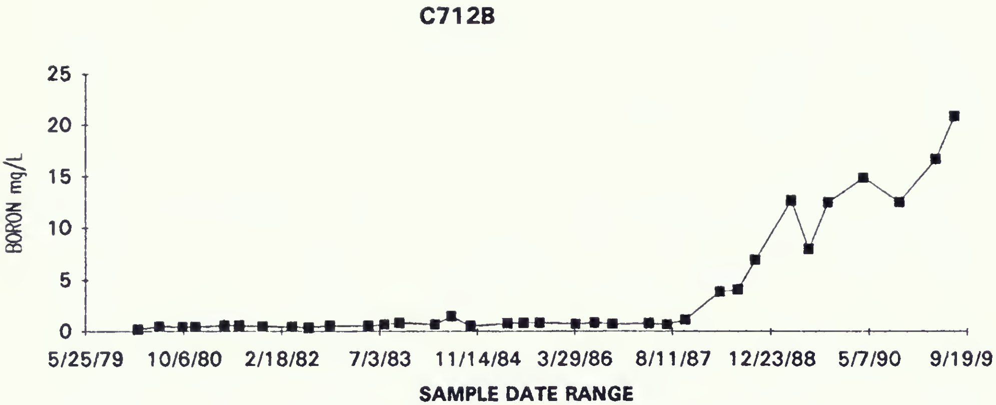

Figure 7.14 Boron in Piezometer C712B.

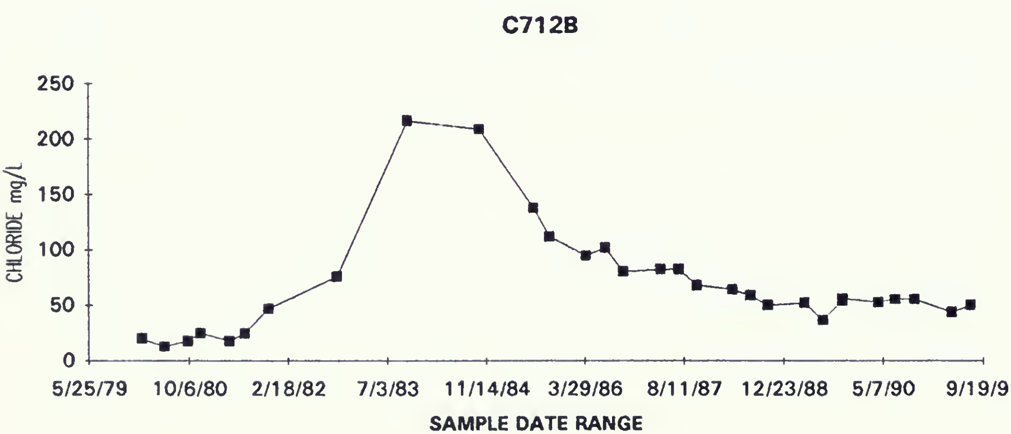

Figure 7.15 Chloride in Piezometer C712B.

Following the completion of the work, the ash surcharge was surveyed to determine the slope of the ash. No slope was determined to be greater than 25%.

While the work was being done on Ash Lagoon No. 1, a small ash dyke was constructed at the south end of Ash Lagoon No. 2. This action became necessary to prevent ash or ash water discharging from Ash Lagoon No. 1 over Dyke "C" at the south of Ash Lagoon No. 2. Over the next several years it is anticipated that more ash dykes will be built on Ash Lagoon No. 2, as the surcharging project continues. Figure 7.16 shows the built up dykes on Ash Lagoons No. 1 and No. 2 as well as the condition of the other cells for December 31, 1991.

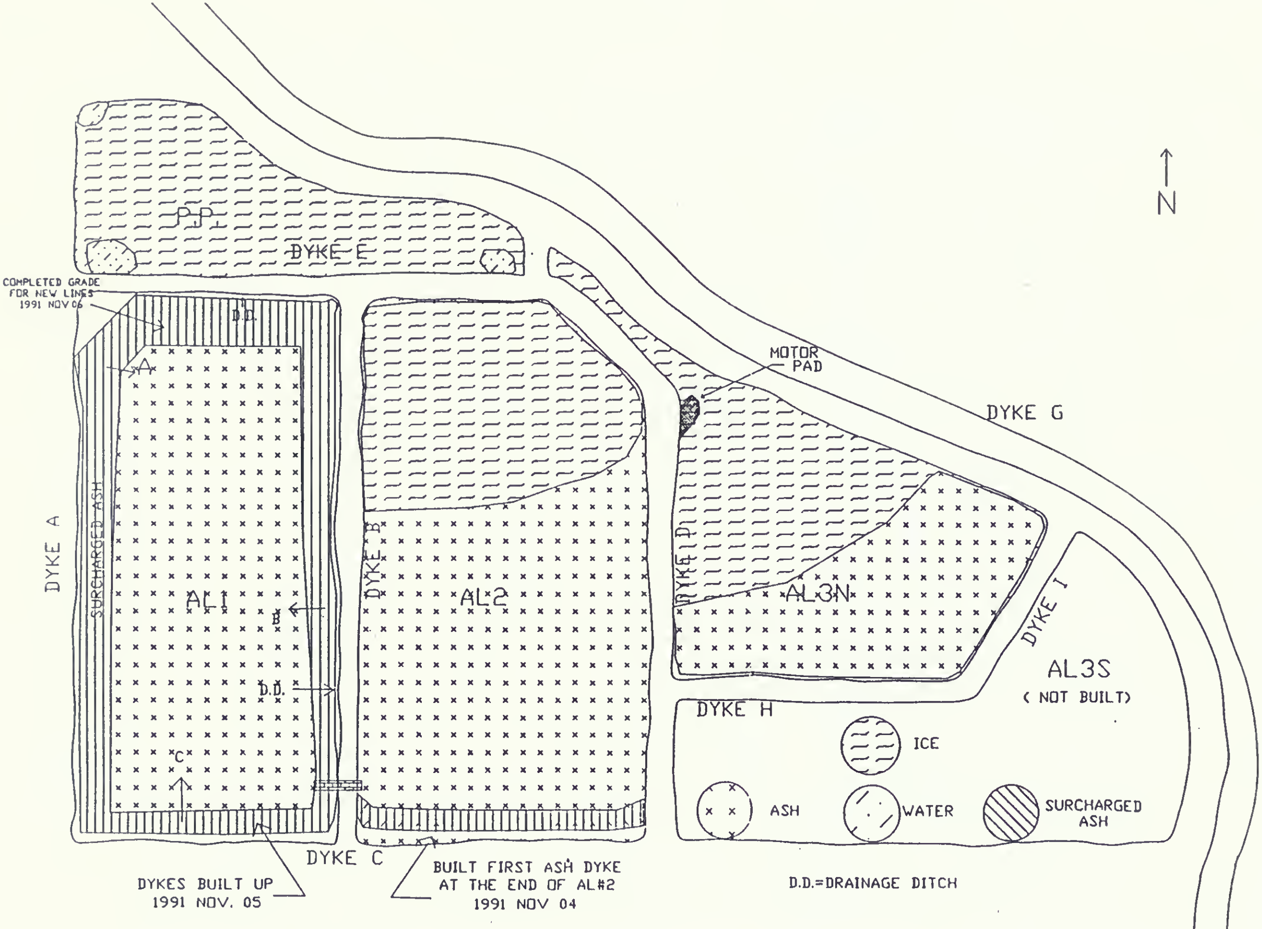

Figure 7.16 Dykes on Ash Lagoons, December 31, 1991.

8.0 SEWAGE HOLDING POND

8.1 Operations

There was no change in the operation of the sewage holding pond during 1991. Effluent from the sewage treatment plant is disposed of in the polishing pond after a period in the sewage holding pond. The total amount of sewage transferred in 1991 is estimated at 1955 m^3. Neither ash nor ash water was added during 1991.

8.2 Pond Quality

Table 8.1 provides the results from the various points comprising the sewage facilities. There is no indication of an increasing trend in the polishing pond that would suggest an impact from the sewage facilities.

Table 8.1 Waste Water Data, November 1991, Poplar River Power Station.

Parameter*	Sewage Inlet	Sewage Outlet	Sewage Holding Pond	Polishing Pond
Chloride	166	127	118	32
Conductivity (µs/cm)	2 450	2 010	2 240	2 830
Total Coliform (Col/100 ml)	27 000	2 600	60	<1
Total Kjeldahl Nitrogen	48	4.4	1.6	14.8
Nitrate Nitrogen as N	<0.003	36.3	1.3	---
Total Phosphorous as P	6.6	4.1	1.1	---
Non-Filterable Residue	260	34	13	2.0
Non-Filterable Residue Volatile	214	24	4.4	0.8
5 Day, 20°C Biochemical Oxygen Demand	123.5	10.5	5.7	---

* All concentrations mg/L unless otherwise noted

9.0 AIR QUALITY

9.1 Saskatchewan Environment and Public Safety

During 1991, ambient sulphur dioxide monitoring recorded no violations of Saskatchewan Environment and Public Safety's hourly and 24 hour average standards of 0.17 and 0.06 ppm, respectively. The highest recorded hourly value of 0.137 ppm SO_2 was recorded on September 27 at 16:00 hours, as compared to 0.085 ppm SO_2 recorded in July, 1990. The highest 24-hour average, reading of 0.011 ppm occurred on September 6 as compared to 1990's highest average reading of 0.012 ppm. There was no downtime for the monitor during the 12-month period, compared to 1990's 1.8%. Figures 9.1 and 9.2 display maximum hourly and daily (24-hour) average readings obtained at the monitoring station during the last five years.

Suspended particulate concentrations obtained from the high volume monitor at the same site for the 12-month period exceeded Saskatchewan Environment and Public Safety's 24-hour average standard of 120 $\mu g/m^3$/24 hours on two occasions, September 3 and October 21 at 162.2 $\mu g/m^3$ and 197.7 $\mu g/m^3$, respectively. Wind data for October 21 indicated that winds were blowing from the south to southeast indicating that the power plant could have been a possible source. The annual geometric mean of 31.3 $\mu g/m^3$ is well below the provincial standard of 70.0 and is lower than 1990's annual geometric mean of 35.4 $\mu g/m^3$. Downtime for the monitor was 3.3% compared to 23% in 1990.

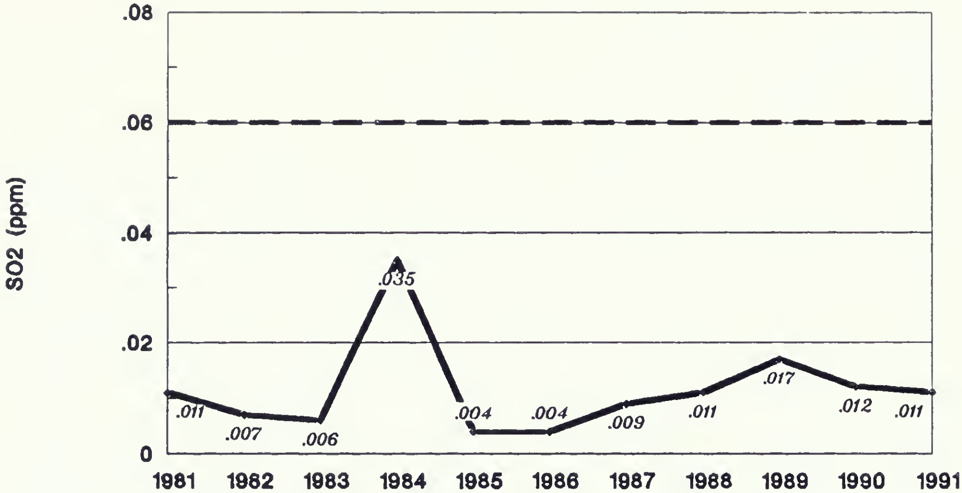

Figure 9.1 Maximum Daily SO_2 Air Quality Data, Coronach Water Treatment Plant, 1981 to 1991, (Saskatchewan 24-hour standard).

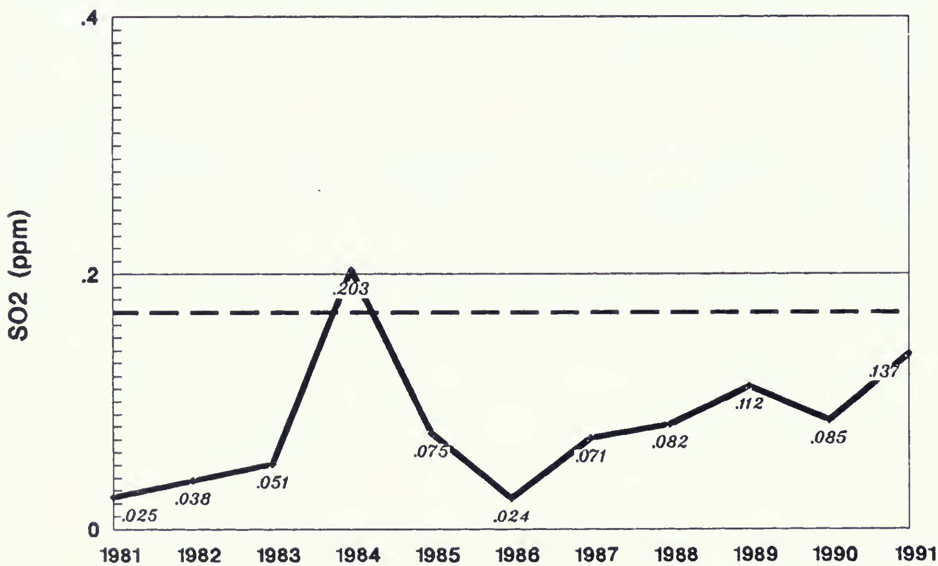

Figure 9.2 Maximum Hourly SO_2 Air Quality Data, Coronach Water Treatment Plant, 1981 to 1991, (Saskatchewan 1-hour standard).

9.2 SaskPower

Ambient SO_2 monitoring conducted at SaskPower's station which is located 8.0 kilometres southeast of the plant, near the 49th parallel, showed no violation for 1991, the same as in 1990. The highest hourly reading of 0.081 ppm occurred on October 17, 1991 at 4:00 hours. Weather data recorded by Environment Canada's weather station located at Rockglen (37 kilometres northwest of the plant) indicated winds blowing from the plant towards the monitor at the time. This reading compares to the highest hourly reading of 0.049 ppm recorded in 1990. Downtime for the monitor was 5.6%, as compared to the 1990's 1.3%.

Suspended particulate concentrations at SaskPower's monitoring station exceeded Saskatchewan Environment and Public Safety's 24-hour standard on two occasions in 1991, compared to five in 1990. The highest recorded value of 173.8 $\mu g/m^3/24$ hours occurred on September 3. This, as well as the other violation, were probably caused by field-blown dust as no specific episodes of heavy particulate release from the plant stack on violation days could be determined. The annual geometric mean of 26.8 $\mu g/m^3$ is well below the provincial standard of 70.0 and compares with the 1990 mean of 35.4. Downtime for the sampler was 6.7%, as compared to 1990's 1.7%.

9.3 In-Stack Monitoring

Sulphur dioxide averages in 1991 were very similar to those in 1990. Daily concentrations ranged from a low of 1165 mg/m^3 to a high of 4421 mg/m^3 (corrected to 3% O_2) with an averaged yearly concentration of 2876 mg/m^3 as compared to 2896 mg/m^3 in 1990. Downtime for the SO_2 in stack monitor was 19%, slightly higher than 1990's 16%. Nitrogen oxide averages in 1991 were similar to those in 1990, with daily concentrations ranging from a low of 440 mg/m^3 to a high of 1047 mg/m^3 (corrected to 3% O_2) with an average yearly concentration of 719 as compared to 741 in 1990. Downtime for the NO_x in-stack monitor was 24%, up from 1990's 16%. Daily opacity readings ranged from 0 to 100%, with a yearly average of 45% compared to 37% in 1990. Downtime for the opacity monitor was 1% as compared to 1990's 4%. Stack gas flow rates ranged from a low of 466 m^3/s to a high of 714 m^3/s, with an average flow of 651 m^3/s in 1991. Downtime for the 12-month period in 1991 was 1%, the same as 1990's.

Units No. 1 and No. 2 operated with yearly average capacity factors of 88.7 and 86.2% respectively, compared to 88.1% and 88.4% in 1990. Totals combining both units were as follows:

Coal - 3 841 000 kg in 1991, compared to 3 821 978 kg in 1990.

Oil - 1823 m^3 in 1991, compared to 2102 m^3 in 1990.

Gross Megawatt Hours - 4 534 100 in 1991 compared to 4 574 700 in 1990.

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ANNEX 1

POPLAR RIVER

COOPERATIVE MONITORING ARRANGEMENT

CANADA-UNITED STATES

September 23, 1980

POPLAR RIVER COOPERATIVE MONITORING ARRANGEMENT

I. PURPOSE

This Arrangement will provide for the exchange of data collected as described in the attached Technical Monitoring Schedules in water quality, water quantity and air quality monitoring programs being conducted in Canada and the United States at or near the International Boundary in response to SaskPower development. This Arrangement will also provide for the dissemination of the data in each country and will assure its comparability and assist in its technical interpretation.

The Arrangement will replace and expand upon the quarterly information exchange program instituted between Canada and the United States in 1976.

II. PARTICIPATING GOVERNMENTS

Governments and government agencies participating in the Arrangement are:

Government of Canada: Environment Canada
Government of the Province of Saskatchewan:
    Saskatchewan Environment and Public Safety
Government of the United States of America: U.S. Geological Survey
Government of the State of Montana: Executive Office

III. POPLAR RIVER MONITORING COMMITTEE: TERMS OF REFERENCE

A binational committee called the Poplar River Bilateral Monitoring Committee will be established to carry out responsibilities assigned to it under this Arrangement. The Committee will operate in accordance with the following terms of reference:

A. Membership

The Committee will be composed of four representatives, one from each of the participating Governments. It will be jointly chaired by the Government of Canada and the Government of the United States. There will be a Canadian Section and a United States Section. The participating Governments will notify each other of any changes in membership on the Committee. Co-chairpersons may by mutual agreement invite agency technical experts to participate in the work of the Committee.

The Governor of the State of Montana may also appoint a chief elective official of local government to participate as an ex-officio member of the Committee in its technical deliberations. The Saskatchewan Minister of the Environment may also appoint a similar local representative.

B. Functions of the Committee

The role of the Committee will be to fulfill the purpose of the Arrangement by ensuring the exchange of monitored data in accordance with the attached Technical Monitoring Schedules, and its collation and technical interpretation in reports to Governments on implementation of the Arrangement. In addition, the Committee will review the existing monitoring systems to ensure their adequacy and may recommend to the Canadian and United States Governments any modifications to improve the Technical Monitoring Schedules.

1. Information Exchange

Each Co-chairperson will be responsible for transmitting to his counterpart Co-chairperson on a regular, and not less than quarterly basis, the data provided by the cooperative monitoring agencies in accordance with the Technical Monitoring Schedules.

2. Reports

(a) The Committee will prepare a joint Annual Report to the participating governments, and may at any time prepare joint Special Reports.

(b) Annual Reports will

i) summarize the main activities of the Committee in the year under Report and the data which has been exchanged under the Arrangement;

ii) draw to the attention of the participating governments any definitive changes in the monitored parameters, based on collation and technical interpretation of exchanged data (i.e. the utilization of summary, statistical and other appropriate techniques);

iii) draw to the attention of the participating governments any recommendations regarding the adequacy or redundancy of any scheduled monitoring operations and any proposals regarding modifications to the Technical Monitoring Schedules, based on a continuing review of the monitoring programs including analytical methods to ensure their comparability.

c) Special Reports may, at any time, draw to the attention of participating governments definitive changes in monitored parameters which may require immediate attention.

d) Preparation of Reports

Reports will be prepared following consultation with all committee members and will be signed by all Committee members. Reports will be separately forwarded by the Committee Co-chairmen to the participating governments. All annual and special reports will be so distributed.

3. Activities of Canadian and United States Sections

The Canadian and United States section will be separately responsible for:

(a) dissemination of information within their respective countries, and the arrangement of any discussion required with local elected officials;

(b) verification that monitoring operations are being carried out in accordance with the Technical Monitoring Schedules by cooperating monitoring agencies;

(c) receipt and collation of monitored data generated by the cooperating monitoring agencies in their respective countries as specified in the Technical Monitoring Schedules;

(d) if necessary, drawing to the attention of the appropriate government in their respective countries any failure to comply with a scheduled monitoring function on the part of any cooperating agency under the jurisdiction of that government, and requesting that appropriate corrective action be taken.

IV. PROVISION OF DATA

In order to ensure that the Committee is able to carry out the terms of this Arrangement, the participating governments will use their best efforts to have cooperating monitoring agencies, in their respective jurisdictions provide on an ongoing basis all scheduled monitored data for which they are responsible.

V. TERMS OF THE ARRANGEMENT

The Arrangement will be effective for an initial term of five years and may be amended by agreement of the participating governments. It will be subject to review at the end of the initial term and will be renewed thereafter for as long as it is required by the participating governments.

ANNEX 2

POPLAR RIVER

COOPERATIVE MONITORING ARRANGEMENT

TECHNICAL MONITORING SCHEDULES

1992

CANADA-UNITED STATES

TABLE OF CONTENTS

PREAMBLE

The Technical Monitoring Schedule lists those water quantity, water quality and air quality monitoring locations and parameters which form the basis for information exchange and reporting to Governments. The structure of the Committee responsible for ensuring the exchange takes place is described in the Poplar River Cooperative Monitoring Arrangement.

The monitoring locations and parameters listed herein have been reviewed by the Poplar River Bilateral Monitoring committee and represent the basic technical information needed to identify any definitive changes in water quantity, water quality and air quality at the International Boundary. The Schedule was initially submitted to Governments for approval as an attachment to the 1981 report Governments. Changes in the sampling locations and parameters may be made by Governments based on the recommendations of the committee.

Significant additional information is being collected by agencies on both sides of the International Boundary, primarily for project management or basin-wide baseline data purposes. This additional information is usually available upon request from the collecting agency and forms part of the pool of technical information which may be drawn upon by Governments for specific study purposes. Examples of additional information are water quantity, water quality, groundwater and air quality data collected at points in the Poplar River basin not of direct concern to the Committee. In addition, supplemental information on parameters such as vegetation, soils, fish and waterfowl populations and aquatic vegetation is also being collected on either a routine or specific studies basis by various agencies.

POPLAR RIVER

COOPERATIVE MONITORING ARRANGEMENT

TECHNICAL MONITORING SCHEDULES

1992

CANADA

STREAMFLOW MONITORING

Responsible Agency: Environment Canada

Daily mean discharge or levels and instantaneous monthly extremes as normally published in surface water data publications.

No. on Map	Station No.	Station Name
*1	11AE003 (06178500)	East Poplar River at International Boundary
2	11AE013	Cookson Reservoir near Coronach
3	11AE015	Girard Creek near Coronach Cookson Reservoir
4	11AE014	East Poplar River above Cookson Reservoir
5	**Fife Lake Overflow	
*6	11AE008 (06178000)	Poplar River at International Boundary

* - International gauging station

** - Miscellaneous measurements of outflow to be made by Sask Water during periods of outflow only.

HYDROMETRIC GAUGING STATIONS (CANADA)

SURFACE WATER QUALITY

Sampling Locations

Responsible Agency: Saskatchewan Environment and Public Safety		
No. on Map	**Station No.**	**Station Name**
1	7904	Fife Lake Overflow
2	12412 Discontinued	Girard Creek at Coronach Reservoir Outflow
3	12377 Discontinued	Upper End of Cookson Reservoir at Highway 36
4	12368	Cookson Reservoir near Dam
5	12386 Discontinued	East Poplar River at Culvert Immediately Below Cookson Reservoir

Responsible Agency: Environment Canada		
No. on Map	**Station No.**	**Station Name**
6	00SA11AE0008	East Poplar River at International Boundary

PARAMETERS

Responsible Agency: Saskatchewan Environment and Public Safety							
ESQUADAT* Code	Parameter	Analytical Method	Sampling Frequency Station No.				
			1	2	3	4	5
10151	Alkalinity-phenol	Pot. Titration	OF	Q	Q	Q	Q
10101	Alkalinity-tot	Pot. Titration	OF	Q	Q	Q	Q
13004	Aluminum tot	AA-direct		A	A	A	A
33004	Arsenic-tot	Flameless-A.A.		A	A	A	A
06201	Bicarbonates	Calculated	OF	Q	Q	Q	Q
05451	Boron-tot	ICAP	W	Q	Q	Q	Q
48002	Cadmium-tot	AA-Solvent extract (MIBK)		A	A	A	A
20103	Calcium	AA-direct	OF	Q	Q	Q	Q
06052	Carbon-tot Inorg.	Infrared	OF		Q	Q	Q
06005	Carbon-tot Org.	Infrared	OF		Q	Q	Q
06301	Carbonates	Calculated	OF	Q	Q	Q	Q
17203	Chloride	Automated Colourimetric	OF	Q	Q	Q	Q
06711	Chlorophyll 'a'	Spectrophotometry		Q	Q	Q	Q
24004	Chromium-tot	AA-Direct		A	A	A	A
36012	Coliform-fec	Membrane Filtration	OF	Q	Q	Q	Q
36002	Coliform-tot	Membrane Filtration	OF	Q	Q	Q	Q
02041	Conductivity	Conductivity Meter	W	Q	Q	Q	Q
29005	Copper-tot	AA-Solvent extract (MIBK)		A	A	A	A
09105	Fluoride	Specific ion electrode		A	A	A	A
82002	Lead-tot	AA-Solvent extract (MIBK)		A	A	A	A
12102	Magnesium	AA-Direct	OF	Q	Q	Q	Q
80011	Mercury-tot	Flameless AA		A	A	A	A
42005	Molybdenum	AA-Solvent extract (MIBK)		A	A	A	A
07015	N-TKN	Automated Colourimetric	OF	Q	Q	Q	Q
10401	NFR	Gravimetric	OF	Q	Q	Q	Q
10501	NFR (F)	Gravimetric	OF	Q	Q	Q	Q
28002	Nickel-tot	AA-Solvent extract (MIBK)	OF	Q	Q	Q	Q
07110	Nitrate + NO_2	Automated Colourimetric	OF	Q	Q	Q	Q
06521	Oil and Grease	Pet. Ether Extraction		A	A	A	A
08102	Oxygen-diss	Meter	OF	Q	Q	Q	Q
15406	Phosphorus-tot	Colourimetry	OF	Q	Q	Q	Q
19103	Potassium	Flame Photometry	OF	Q	Q	Q	Q
34005	Selenium-Ext	Hydride Generation		A	A	A	A
11103	Sodium	Flame Photometry	OF	Q	Q	Q	Q
16306	Sulphate	Colourimetry	OF	Q	Q	Q	Q
10451	TDS	Gravimetric	OF	Q	Q	Q	Q
02061	Temperature	Thermometer	OF	Q	Q	Q	Q
23004	Vanadium-tot	AA-Direct		A	A	A	A
30005	Zinc-tot	AA-Solvent extract (MIBK)		A	A	A	A
10301	pH	Electrometric	W	Q	Q	Q	Q

* Computer storage and retrieval system - Saskatchewan Environment and Public Safety.

Symbols:

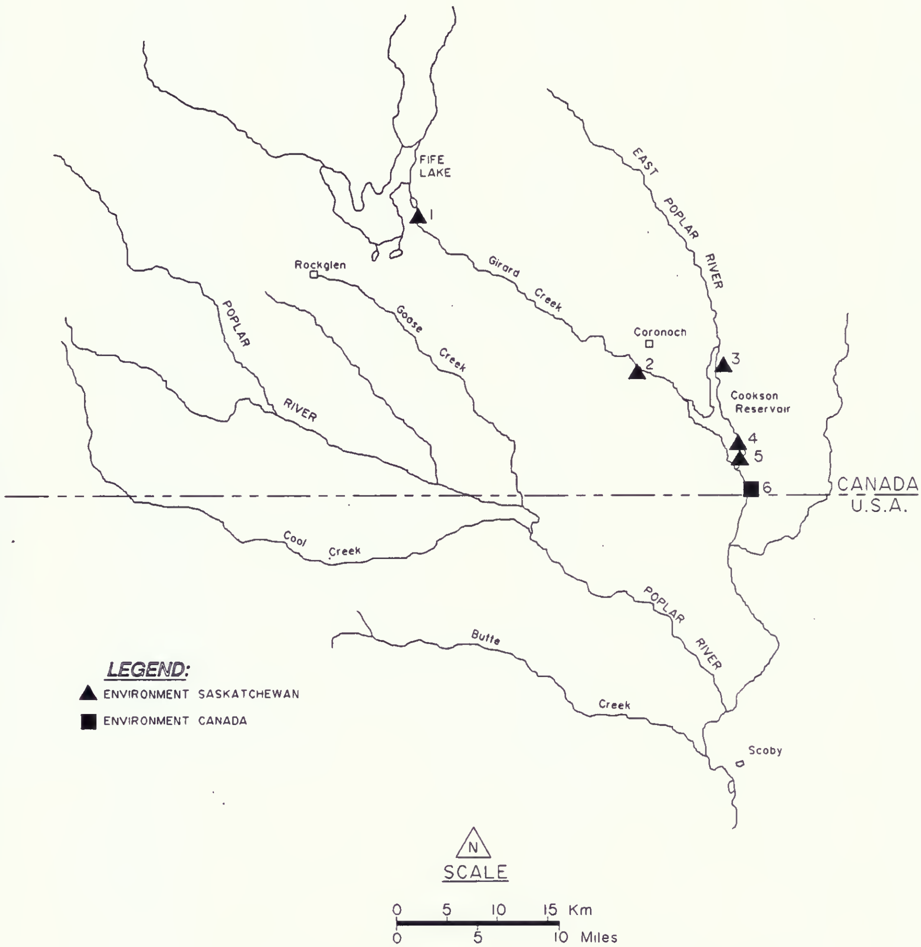
W - Weekly during overflow; **OF** - Once during each period of overflow greater than 2 weeks' duration;
Q - Quarterly; **A** - Annually in the fall; **AA** - Atomic absorption;
Pot - Potentiometric; **NFR** - Nonfilterable residue; **NFRF** - Nonfilterable residue, fixed;
ICAP - Inductively Coupled Argon Plasma;
AA - Solvent Extract (MIBK) - Sample digested with HNO_3 and extracted with methyl isobutyl ketone;

PARAMETERS (Continued)

Responsible Agency: Environment Canada			
NAQUADAT* Code	Parameter	Analytical Method	Sampling Frequency Station No. 6
10151	Alkalinity-phenolphthalein	Potentiometric Titration	BM
10111	Alkalinity-total	Potentiometric Titration	BM
13102	Aluminum-dissolved	AA-Direct	BM
13302	Aluminum-extracted	AA-Direct	BM
07570	Ammonia-free	Calculated	BM
07540	Ammonia-total	Automated Colourimetric	BM
33108	Arsenic-dissolved	ICAP-hydride	BM
56001	Barium-total	AA-Direct	BM
06201	Bicarbonates	Calculated	BM
05211	Boron-dissolved	ICAP	BM
96360	Bromoxynil	Gas Chromatography	BM
48002	Cadmium-total	AA Solvent Extraction	BM
20103	Calcium	AA-Direct	BM
06104	Carbon-dissolved organic	Automated IR Detection	BM
06901	Carbon-particulate	Elemental Analyzer	BM
06002	Carbon-total organic	Calculated	BM
06301	Carbonates	Calculated	BM
17206	Chloride	Automated Colourimetric	BM
06717	Chlorophyll a	Spectrophotometric	BM
24003	Chromium-total	AA-Solvent Extraction	BM
27002	Cobalt-total	AA-Solvent Extraction	BM
36012	Coliform-fecal	Membrane Filtration	BM
36002	Coliform-total	Membrane Filtration	BM
02021	Colour	Comparator	BM
02041	Conductivity	Wheatstone Bride	BM
29005	Copper-total	AA-Solvent Extraction	BM
06610	Cyanide	Automated UV-Colourimetric	BM
09117	Fluoride-dissolved	Electrometric	BM
06401	Free Carbon Dioxide	Calculated	BM
10602	Hardness	Calculated	BM
17811	Hexachlorobenzene	Gas Chromatography	BM
08501	Hydroxide	Calculated	BM
26104	Iron-dissolved	AA-Direct	BM
82002	Lead-total	AA-Solvent Extraction	BM
12102	Magnesium	AA-Direct	BM
25104	Manganese-dissolved	AA-Direct	BM
80011	Mercury-total	Flameless AA	BM
07901	N-particulate	Elemental Analyzer	BM
07651	N-total dissolved	Automated UV Colourimetric	BM
10401	NFR	Gravimetric	BM
28002	Nickel-total	AA-Solvent Extraction	BM
07110	Nitrate/Nitrite	Colourimetric	BM
07603	Nitrogen-total	Calculated	BM
10650	Non-Carbonate Hardness	Calculated	BM
18XXX	Organo Chlorines	Gas Chromatography	BM
08101	Oxygen-dissolved	Winkler	BM
15901	P-particulate	Calculated	BM
15465	P-total dissolved	Automated Colourimetric	BM
185XX	Phenoxy Herbicides	Gas Chromatography	BM
15423	Phosphorus-total	Colourimetric (TRAACS)	BM
19103	Potassium	Flame Emission	BM
11250	Percent Sodium	Calculated	BM
00210	Saturation Index	Calculated	BM
34108	Selenium-dissolved	ICAP-hydride	BM
14108	Silica	Automated Colourimetric	BM
11103	Sodium	Flame Emission	BM
00211	Stability Index	Calculated	BM
16306	Sulphate	Automated Colourimetric	BM
00201	TDS	Calculated	BM
02061	Temperature	Digital Thermometer	BM
02073	Turbidity	Nephelometry	BM
23002	Vanadium-total	AA-Solvent Extraction	BM
30005	Zinc-total	AA-Solvent Extraction	BM
10301	pH	Electrometric	BM
92111	Uranium	Fluometric	MC

* - Computer Storage and Retrieval System -- Environment Canada

AA - Atomic Absorption
IR - Infrared
UV - Ultraviolet
NFR - Nonfilterable Residue
MC - Monthly Composite
BM - Bimonthly (Alternate months sampled by U.S.G.S.)
ICAP - Inductively Coupled Argon Plasma



SURFACE WATER QUALITY MONITORING STATIONS (CANADA)

GROUND WATER QUALITY MONITORING
SAMPLING LOCATIONS

Responsible Agency: Saskatchewan Environment and Public Safety			
		STATION DESCRIPTION	
Map Location No.	SPC Piezometer No.	Tip of Screen Elevation (m)	Material
8a	C726A**	746.338	unoxidized till
8a	C762C**	752.739	oxidized till
8a	C726E**	738.725	Empress gravel
9a	C728A**	753.405	oxidized till
9a	C728B**	743.265	unoxidized till
9a	C728C**	747.645	mottled till
9a	C728D**	752.305	oxidized till
9a	C728E**	739.912	Empress gravel
2a	C712B	746.112	intra till sands
2b	C718**	748.385	mottled till
2c	C719**	747.715	oxidized till
22	C533**	740.441	Empress gravel
23	C534**	753.449	oxidized till
18	C741**	735.153	Empress gravel
21	C742**	741.800	Empress gravel
24	C714A**	745.333	unoxidized till
25	C714D**	750.459	oxidized till
26	C714E**	738.230	Empress gravel
27	C774B**	749.370	oxidized till
28	C775A**	753.320	oxidized till
29	C775D**	740.190	Empress gravel
2a	C712A	--	unoxidized till
2a	C712C	--	mottled till
2a	C712D	--	oxidized till
2a	C766	--	intra till sands
2a	C767	--	intra till sands
7a	C729A**	--	unoxidized till
7a	C729B**	--	mottled till
7a	C729D**	--	oxidized till
7a	C729E**	--	Empress gravel
6a	C763A**	--	mottled till
6a	C763B**	--	oxidized till
6a	C763D**	--	unoxidized till
6a	C763E**	--	Empress gravel
10	C749**	--	mottled till
7	C655A**	--	unoxidized till
3	C713**	--	oxidized till
4	C714C**	--	oxidized till
5	C715**	--	oxidized till
1	C716**	--	oxidized till
13	C745**	--	oxidized till
21	C753**	--	oxidized till
28	C755B**	--	oxidized till
4	C776A**	--	oxidized till
4	C776B**	--	oxidized till
5	C758**	--	intra till sands
C653A	C653A**	--	unoxidized till
4	C757**	--	unoxidized till
27	C774C**	--	unoxidized till
28	C775C**	--	unoxidized till
24	C750**	--	unoxidized till
23	C751**	--	unoxidized till
22	C752**	--	unoxidized till
1	C731**	--	Empress gravel
C739	C739**	--	Empress gravel
27	C774D**	--	Empress gravel
28	C775D**	--	Empress gravel
23	C732**	--	Empress gravel
22	C733**	--	Empress gravel
24	C734**	--	Empress gravel
C531	C531**	--	Oxidized till
C529	C529**	--	Empress gravel
C530	C530**	--	Empress gravel
C532	C532**	--	Empress gravel
C538	C538**	--	Empress gravel

** Analyze annually for all Parameters on A2-12 (except conductivity and water level) -- Information not available

PARAMETERS

Responsible Agency: Saskatchewan Environment and Public Safety			
ESQUADAT* Code	Parameter	Analytical Method	Sampling Frequency Station No.: Piezometers
10101	Alkalinity-tot	Pot-Titration	A
13105	Aluminum-Diss	AA-Direct	3**
33104	Arsenic-Diss	Flameless AA	A
56104	Barium-Diss	AA-Direct	A
06201	Bicarbonates	Calculated	A
05106	Boron-Diss	Colourimetry	3**
48102	Cadmium-Diss	AA-Solvent Extract (MIBK)	A
20103	Calcium-Diss	AA-Direct	A
06301	Carbonates	Calculated	A
17203	Chloride-Diss	Colourimetry	A
24104	Chromium-Diss	AA-Direct	A
27102	Cobalt-Diss	AA-Solvent Extract (MIBK)	A
02011	Colour	Comparator	A
02041	Conductivity	Conductivity Meter	4**
29105	Copper-Diss	AA-Solvent Extract (MIBK)	A
09103	Fluoride-Diss	Specific Ion Electrode	A
26104	Iron-Diss	AA-Direct	A
82103	Lead-Diss	AA-Solvent Extract (MIBK)	A
12102	Magnesium-Diss	AA-Direct	A
25104	Manganese-Diss	AA-Direct	A
80111	Mercury-Diss	Flameless AA	A
42102	Molybdenum-Diss	AA-Solvent Extract (N-Butyl acetate)	A
10301	pH	Electrometric	3**
19103	Potassium-Diss	Flame Photometry	A
34105	Selenium-Diss	Hydride generation	A
14102	Silica-Diss	Colourimetry	A
11103	Sodium-Diss	Flame Photometry	A
38101	Strontium-Diss	AA-Direct	3**
16306	Sulphate-Diss	Colourimetry	3**
10451	TDS	Gravimetric	3**
92111	Uranium-Diss	Fluorometry	3**
23104	Vanadium-Diss	AA-Direct	A
97025	Water Level		4
30105	Zinc-Diss	AA-Solvent Extract (MIBK)	A

No zinc or iron for Piezometers C531 to C538.

* Computer storage and retrieval system

-- Saskatchewan Environment and Public Safety

** Analyze annually for these Piezometers Nos.

SYMBOLS: **AA** - Atomic absorption

A - Annually

3 - 3 times/year

AA - Solvent Extract (MIBK) - sample acidified and extracted with Methyl Isobutyl Ketone.

GROUND WATER PIEZOMETERS TO MONITOR POTENTIAL DRAWDOWN DUE TO COAL SEAM DEWATERING

Responsible Agency: Saskatchewan Environment and Public Safety			
Measurement Frequency: Quarterly			
Piezometer Number	Location	Tip of Screen Elevation (m)	Perforation Zone (depth in metres)
52	NW 14-1-27 W3	738.43	43 - 49 (in coal)
506A	SW 4-1-27 W3	748.27	81 - 82 (in coal)
507	SW 6-1-26 W3	725.27	34 - 35 (in coal)
509	NW 11-1-27 W3	725.82	76 - 77 (in coal)
510	NW 1-1-28 W3	769.34	28 - 29 (in layered coal and clay)

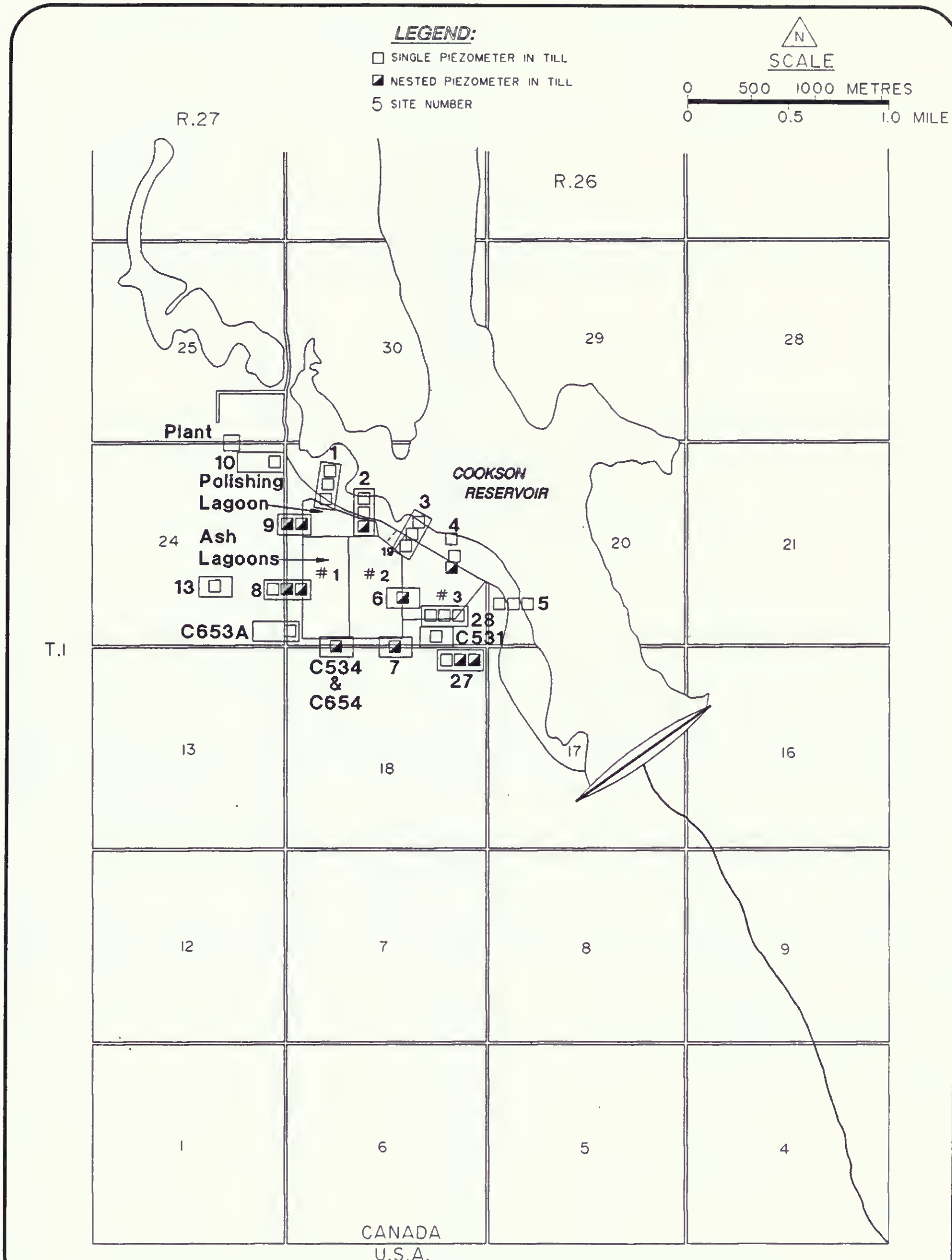
GROUNDWATER PIEZOMETERS TO MONITOR POTENTIAL DRAWDOWN DUE TO COAL SEAM DEWATERING

GROUNDWATER PIEZOMETER LEVEL MONITORING -- ASH LAGOON AREA

Schedule A -- Piezometers in Till

Responsible Agency: Saskatchewan Environment and Public Safety

STATION	PIEZOMETER NO.	FREQUENCY OF MEASUREMENT
1a	C716	All piezometer levels are measured quarterly.
1b	C717	
1c	C711	
1	C765	
$2a_1$	C712A	
$2a_2$	C712B	
$2a_3$	C712C	
$2a_4$	C712D	
2b	C718	
2c	C719	
3a	C713	
3b	C720	
3c	C721	
4	C714B	
4	C722	
4	C723	
5	C724	
5	C725	
$6a_1$	C763A	
$6a_2$	C763B	
$6a_3$	C763C	
$6a_4$	C763D	
6b	C765B	
6b	C765C	
6b	C765D	
6b	C765E	
6c	C767B	
$7a_1$	C729A	
$7a_2$	C729B	
$7a_3$	C729C	
$7a_4$	C729D	
7	C655B	
C534	C534	
C528	C528	
C654	C654	
$8a_1$	C730A	
$8b_1$	C727A	
$8b_2$	C727B	
$8b_3$	C727C	
$8c_1$	C726A	
$8c_2$	C726B	
$8c_3$	C726C	
8d	C748	
$9a_1$	C764A	
$9a_2$	C764B	
$9a_3$	C764C	
$9a_4$	C764D	
$9b_1$	C728A	
$9b_2$	C728B	
$9b_3$	C728C	
$9b_4$	C728D	
11	C747	
15	C746	
28	C768C	
28	C768D	
28	C768E	

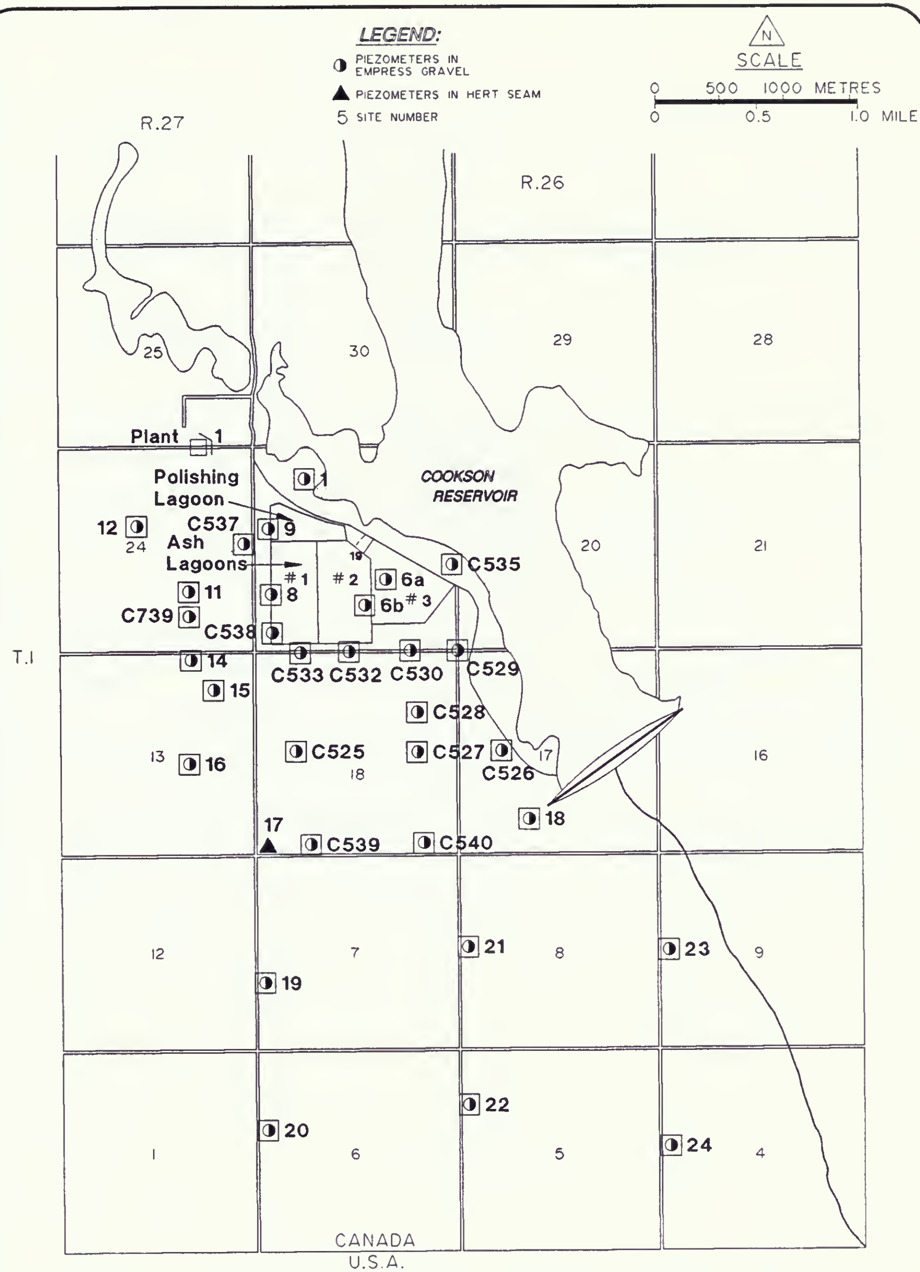


PIEZOMETER INSTALLATION SITES–SCHEDULE "A" PIEZOMETERS IN TILL

GROUNDWATER PIEZOMETER LEVEL MONITORING
-- ASH LAGOON AREA AND INTERNATIONAL BOUNDARY AREA
Schedule B - Piezometers in Empress Gravel

Responsible Agency: Saskatchewan Environment and Public Safety		
STATION	**PIEZOMETER NO.**	**FREQUENCY OF MEASUREMENT**
IMMEDIATE ASH LAGOON AREA		
1	C731	All piezometers are monitored quarterly
6a	C763E	
6b	C765A	
C529	C529	
C530	C530	
C532	C532	
C533	C533	
C538	C538	
8	C730E	
9	C728E	
9	C764E	
6b	C765A	
4	C766A	
6c	C767A	
28	C768A	
C535	C535	
1	C536	
C537	C537	
3	C542	
WEST OF ASH LAGOON AREA		
11	C743	All piezometers are monitored quarterly
14	C740	
16	C756	
12	C737	
SOUTH OF ASH LAGOON AREA		
C525	C525	All piezometers are monitored quarterly
C526	C526	
C527	C527	
C539	C539	
C540	C540	
18	C741	
20*	C736	
21	C742	
22	C733	
23	C732	
24	C734	
14	C740	
11	C743	
16	C756	

* Inactive as of 1989



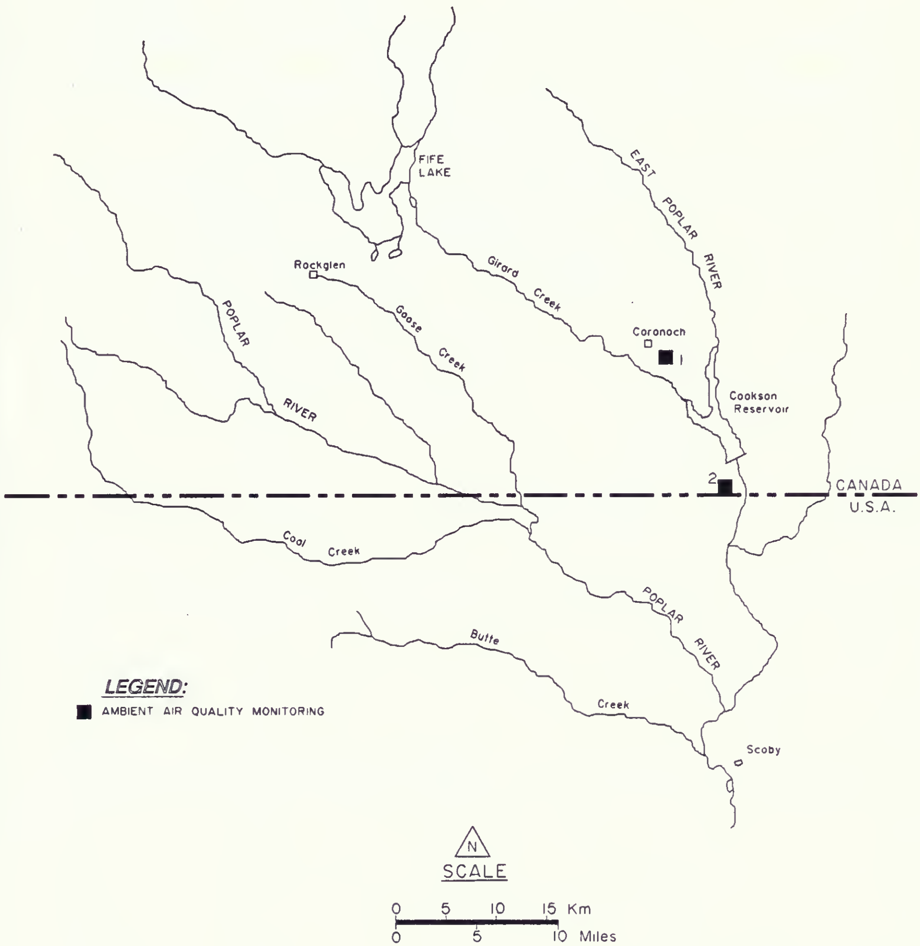
PIEZOMETER INSTALLATION SITES–SCHEDULE "B" PIEZOMETERS IN EMPRESS GRAVEL

AMBIENT AIR QUALITY MONITORING

Responsible Agency: Saskatchewan Environment and Public Safety			
NO. ON MAP	**LOCATION**	**PARAMETERS**	**REPORTING FREQUENCY**
1	Coronach (Discontinued)	Sulphur Dioxide	Continuous monitoring with hourly averages as summary statistics.
		Wind speed and direction	Continuous monitoring with hourly averages as summary statistics.
		Total Suspended Particulate	24-hour samples on a 6-day cycle, corresponding to the National Air Pollution Surveillance Sampling Schedule.
2	International Boundary *	Sulphur Dioxide	Continuous monitoring with hourly averages as summary statistics.
		Total Suspended Particulate	24-hour samples on 6-day cycle, corresponding to the National Air Pollution Surveillance Sampling Schedule.

METHODS	
Sulphur Dioxide	Saskatchewan Environment and Public Safety Colourimetric Titration, Pulsed Fluorescence
Total Suspended Particulate	Saskatchewan Environment and Public Safety High Volume Method

* This station operated by SaskPower.

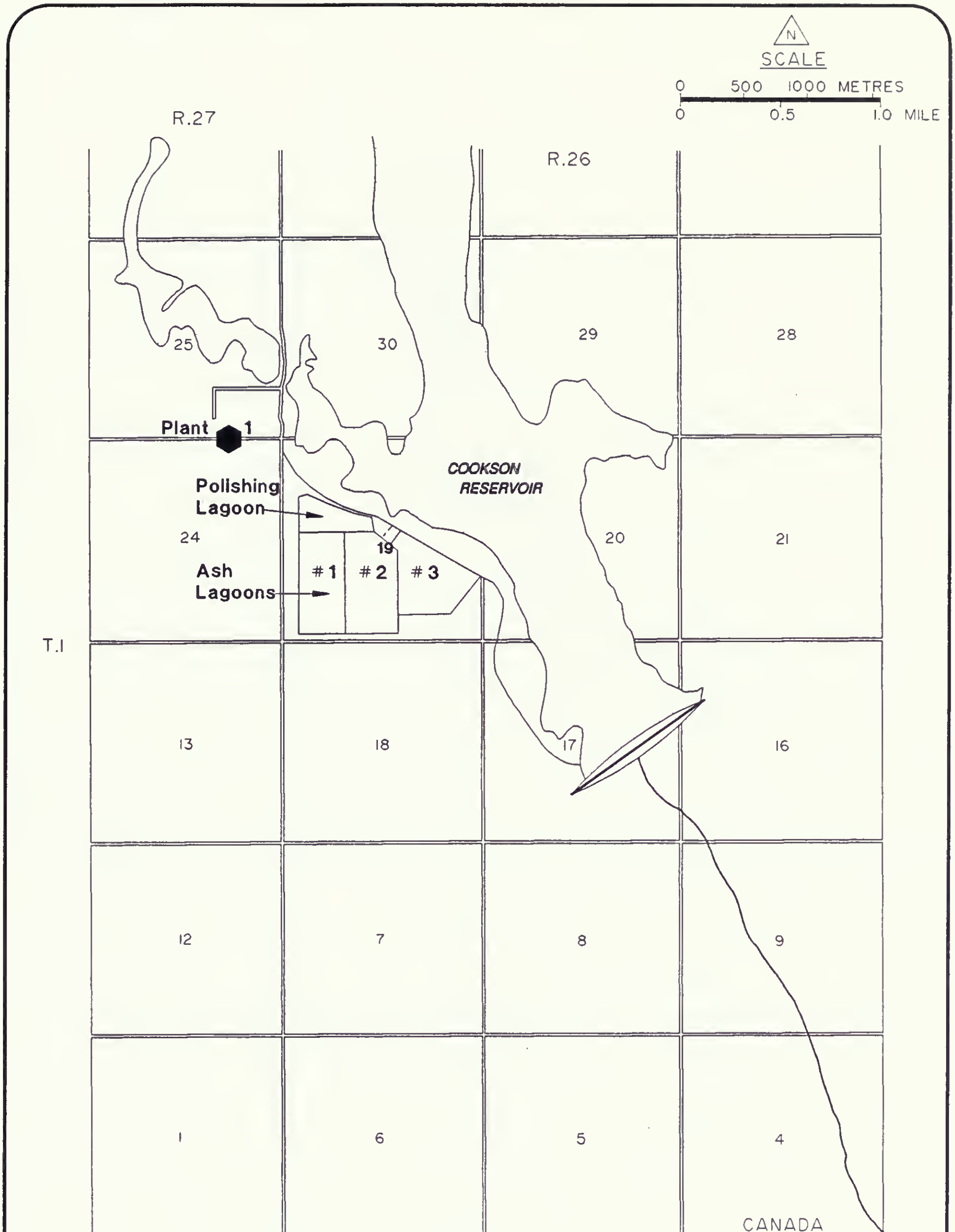


AMBIENT AIR QUALITY MONITORING (CANADA)

SOURCE EMISSION MONITORING

Responsible Agency: Saskatchewan Environment and Public Safety			
No. on Map	**Station Location**	**Parameters**	**Sampling Frequency**
1	At Poplar River Power Plant	Sulphur Dioxide, Nitrogen Dioxide, Opacity.	Continuously reported as Hourly Averages

METHODS	
Sulphur Dioxide	Saskatchewan Environment and Public Safety - Ultraviolet Absorption
Nitrogen Dioxide	Saskatchewan Environment and Public Safety - Chemiluminescence
Opacity	Saskatchewan Environment and Public Safety - Optical



SOURCE EMISSION MONITORING

POPLAR RIVER

COOPERATIVE MONITORING ARRANGEMENT

TECHNICAL MONITORING SCHEDULES

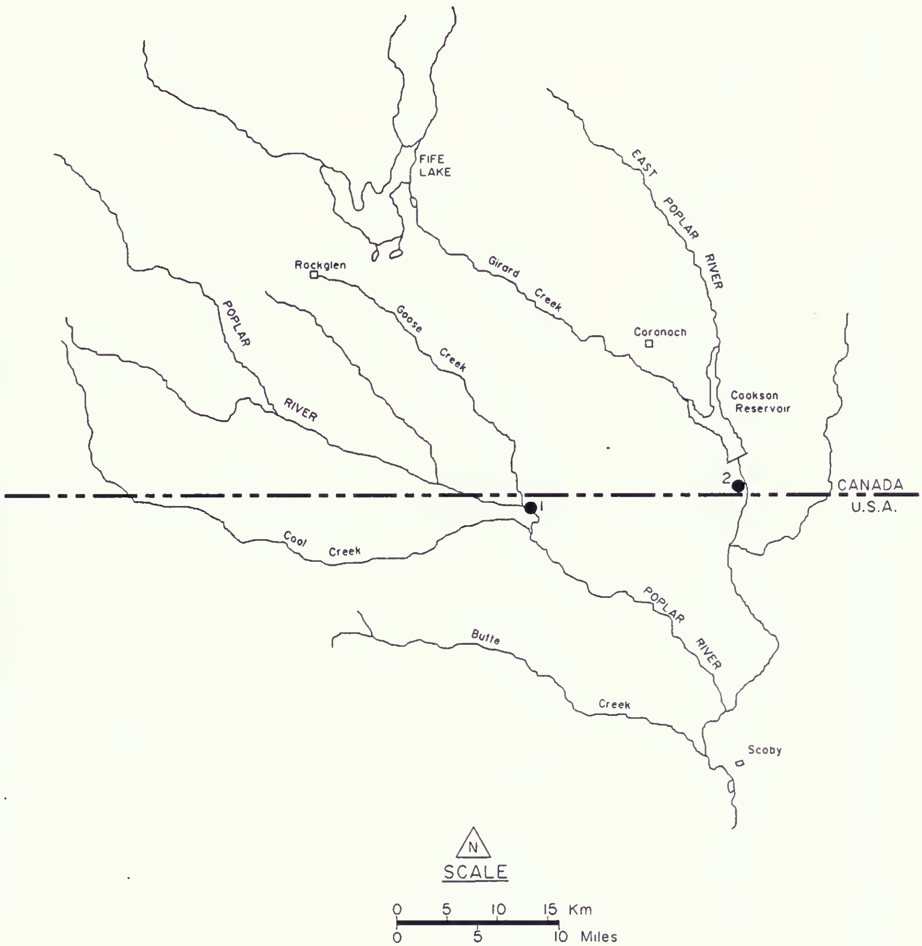
1992

UNITED STATES

STREAMFLOW MONITORING

Responsible Agency: United States Geological Survey		
No. on Map	**Station Number**	**Station Name**
1*	06178000 (11AE008)	Poplar River at International Boundary
2*	06178500 (11AE003)	East Poplar River at International Boundary

* International Gauging Station



HYDROMETRIC GAUGING STATIONS (UNITED STATES)

SURFACE WATER QUALITY MONITORING -- Station Location

Responsible Agency: U.S. Geological Survey

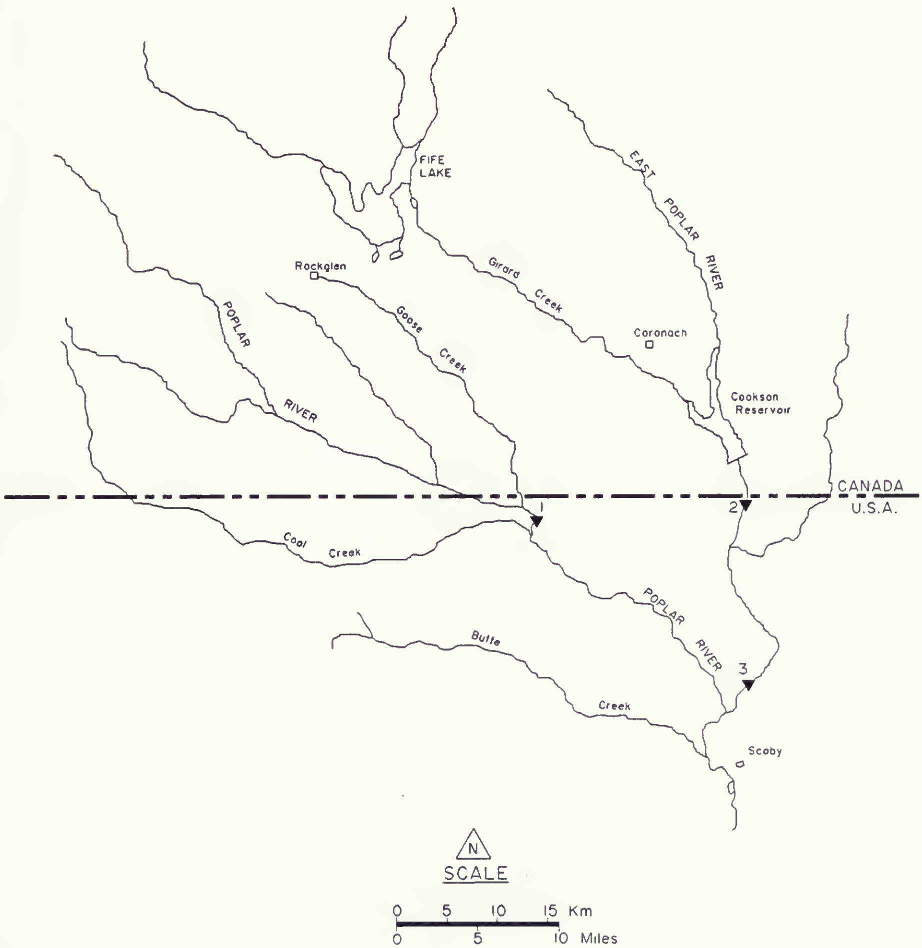
No. on Map	USGS Station No.	Station Name
1	06178000	Poplar River at International Boundary
2	06178500	East Poplar River at International Boundary
3	06179000	East Poplar River near Scobey

PARAMETERS

WATSTORE*			SAMPLING FREQUENCY NO.		
Code	**Parameter**	**Analytical Method**	**1**	**2**	**3**
90410	Alkalinity - lab	Elect. Titration	M	BM	BM
01106	Aluminum - diss	AE, DC Plasma	SA	SA	SA
00610	Ammonia - tot	Colorimetric	M	BM	BM
00625	Ammonia +Org N-tot	Colorimetric	M	BM	BM
01000	Arsenic - diss	AA, hydride	SA	SA	SA
01002	Arsenic - tot	AA, hydride	A	A	A
01010	Beryllium - diss	ICP	SA	SA	SA
01012	Beryllium - tot/rec	AA - Persulfate	A	A	A
01020	Boron - diss	AE, DC Plasma	M	BM	BM
01025	Cadmium - diss	AA, GF	SA	SA	SA
01027	Cadmium - tot/rec	AA, GF - Persulfate	A	A	A
00915	Calcium	ICP	M	BM	BM
00680	Carbon - tot Org	Wet Oxidation	SA	SA	SA
00940	Chloride - diss	Colorimetric	M	BM	BM
01030	Chromium - diss	AE, DC Plasma	SA	SA	SA
01034	Chromium - tot/rec	AE, DC Plasma Persulfate	A	A	A
00080	Colour	Electrometric, visual	M	BM	BM
00095	Conductivity	Wheatstone Bridge	M	D	BM
01040	Copper - diss	AA, GF	SA	SA	SA
01042	Copper - tot/rec	AA, GF - Persulfate	A	A	A
00061	Discharge - inst	Direct measurement	M	BM	BM
00950	Fluoride	Electrometric	M	BM	BM
01046	Iron - diss	AE, ICP	M	BM	BM
01045	Iron - tot/rec	AA-Persulfate	A	A	A
01049	Lead - diss	AA, GF	SA	SA	SA
01051	Lead - tot/rec	AA, GF - Persulfate	A	A	A
00925	Magnesium - diss	AA	M	BM	BM
01056	Manganese - diss	ICP	SA	SA	SA
01055	Manganese - tot/rec	AA-Persulfate	A	A	A
01065	Nickel - diss	AA, GF	SA	SA	SA
01067	Nickel - tot/rec	AA, GF - Persulfate	A	A	A
00615	Nitrite - tot	Colorimetric	M	BM	BM
00630	Nitrate + Nitrite - tot	Colorimetric	M	BM	BM
00300	Oxygen-diss	Winkler/meter	M	BM	BM
70507	Phos, Ortho-tot	Colorimetric	M	BM	BM
00400	pH	Electrometric	M	BM	BM
00665	Phosphorous - tot	Colorimetric	M	BM	BM
00935	Potassium - diss	AA	M	BM	BM
00931	SAR	Calculated	M	BM	BM
80154	Sediment - conc.	Filtration-Gravimetric	M	BM	BM
80155	Sediment - load	Calculated	M	BM	BM
01145	Selenium - diss	AA, hydride	SA	SA	SA
01147	Selenium tot	AA, hydride	A	A	A
00955	Silica	ICP	M	BM	BM
00930	Sodium	ICP	M	BM	BM
00945	Sulphate - diss	Turbimetry	M	BM	BM
70301	Total Dissolved Solids	Calculated	M	BM	BM
00010	Temp Water	Stem Thermometer	M	BM	BM
00020	Temp Air	Stem Thermometer	M	BM	BM
00076	Turbidity	Nephelometric	M	BM	BM
80020	Uranium - diss	Spectrometry	-	MC	-
01090	Zinc - diss	ICP	SA	SA	SA
01092	Zinc - tot/rec	AA-Persulfate	A	A	A

SYMBOLS: **C** - continuous; **D** - daily; **M** - monthly; **BM** - bimonthly; **MC** - monthly composite; **A** - annually at high flow; **SA** - semi-annually at low and high flow; **GF** - graphite furnace **AA** - atomic absorption; **tot** - total; **rec** - recoverable; **diss** - dissolved; **AE** - atomic absorption; **DC** - direct current; **ICP** - inductively coupled plasma;

* - Computer storage and retrieval system - USGS



SURFACE WATER QUALITY MONITORING STATIONS (UNITED STATES)

GROUND WATER QUALITY MONITORING -- Station Locations

Responsible Agency: Montana Bureau of Mines and Geology

Map Number	Well Location	Total Depth (a) (m)	Casing Diameter (cm)	Aquifer	Perforation Zone (m)
2	37N47E17DABB	79	3.8 PVC	Hart Coal	76-79
3	37N47E23AADD	36	3.8 PVC	Hart Coal	33-36
4	37N48E23BBCC	104	3.8 PVC	Fox Hills - Hell Creek	102-104
5*	37N47E1ABBB1	16	10.2 PVC	Alluvium	10-15
6*	37N47E1ABBB2	25	10.2 PVC	Hart Coal	19-25
7*	37N47E12BBBB	14	10.2 PVC	Hart Coal	39-45
8*	37N47E13AADD	63	10.2 PVC	Alluvium	10-13
9*	37N47E13ADAA01	13	10.2 PVC	Fort Union	16-62
10*	37N48E5BABB	67	10.2 PVC	Alluvium-Coal	7-13
11*	37N48E5AAAA	26	15.2 STEEL	Fox Hills - Hell Creek	65-67
12	37N47E Sec 11 DDDD	62.5	5.08	Hart Coal	15-18
13	37N47E Sec 3 CCCC	82.6	10.2	Hart Coal	56-59
14	37N47E Sec 4 BBAB	89	10.2	Hart Coal	75-78
15*	37N47E Sec 3 BBAA	26	10.2	Hart Coal	83-86
16*	37N46E Sec 3 ABAB	88	10.2	Fort Union	24-25
17	37N47E Sec 16 DDDD	90	10.6	Hart Coal	80-83
18	37N46E Sec 1 BBBA	59	10.2	Hart Coal	80-82
19*	37N47E Sec 15 AAAB	22	10.2	Hart Coal	54-56
20	37N47E Sec 24 CCCC	106	5.08	Hart Coal	19-22
21	37N47E Sec 6 DBAA	21	10.2	Hart Coal	100-103
22	37N47E Sec 9 CBCC		10.2	Fort Union	18-21

Parameters

Storet ** Code	Parameter	Analytical Method	Sampling Frequency Station No.
00440	Bicarbonates	Electrometric Titration	Sample collection is annually for all locations identified above.
01020	Boron-diss	Emission Plasma, ICP	
00915	Calcium	Emission Plasma	
00445	Carbonates	Electrometric Titration	The analytical method descriptions are those of the Montana Bureau of Mines and Geology Laboratory where the samples are analyzed.
00940	Chloride	Ion Chromatography	
00095	Conductivity	Wheatstone Bridge	
01040	Copper-diss	Emission Plasma, ICP	
00950	Fluoride	Ion Chromatography	
01046	Irondiss	Emission Plasma, ICP	
01049	Lead-diss	Emission Plasma, ICP	
01130	Lithium-diss	Emission Plasma, ICP	
00925	Magnesium	Emission Plasma, ICP	
01056	Manganese-diss	Emission Plasma, ICP	
01060	Molybdenum	Emission Plasma, ICP	
00630	Nitrate	Ion Chromatography	
00400	pH	Electrometric	
00935	Potassium	Emission Plasma, ICP	
01145	Selenium-diss	AA	
00955	Silica	Emission Plasma, ICP	
00930	Sodium	Emission Plasma, ICP	
01080	Strontium-diss	Emission Plasma, ICP	
00445	Sulphate	Ion Chromatography	
00190	Zinc-diss	Emission Plasma, ICP	
70301	TDS	Calculated	

* - Inactive as of 1989
** - Computer storage and retrieval system -- USGS

SYMBOLS: AA - Atomic Absorption; ICP - Inductively Coupled Plasma Unit

GROUND WATER QUALITY MONITORING (UNITED STATES)

GROUND WATER LEVELS TO MONITOR POTENTIAL DRAWDOWN DUE TO COAL SEAM DEWATERING

Responsible Agency: Montana Bureau of Mines and Geology	
No. on Map	**Sampling**
2 to 22	Determine water levels quarterly

GROUNDWATER PIEZOMETERS TO MONITOR POTENTIAL
DRAWDOWN DUE TO COAL SEAM DEWATERING

ANNEX 3

REPORTS REVIEWED DURING 1991

BY THE POPLAR RIVER BILATERAL MONITORING COMMITTEE

REPORTS REVIEWED DURING 1991

BY THE POPLAR RIVER BILATERAL MONITORING COMMITTEE

Collerson, K.D., D.J. Gregor, D. McNaughton and A.S. Baweja, 1991, Effect of Coal Dewatering and Coal use on the Water Quality of the East Poplar River, Saskatchewan: A Literature Review, Regina, Saskatchewan, Inland Waters Directorate, Scientific Series No. 177, 58 pp.

Integrated Environments Ltd., March 31, 1991, The use of the Tydac SPANS GIS in the assessment and review of pesticide residues detected in surface waters of the Prairie Provinces and the Northwest Territories, Calgary Alberta, 138 pp.

Phillips, Glenn R., Patricia A. Medvick, Donald R. Skaar and Denise E. Knight, 1987, Factors affecting the mobilization, transport and bioavailability of mercury in reservoirs of the Upper Missouri River Basin, U.S. Fish and Wildlife Service, Technical Report 10, 64 pp.

ANNEX 4

RECOMMENDED FLOW APPORTIONMENT

IN THE POPLAR RIVER BASIN

BY THE INTERNATIONAL SOURIS-RED RIVERS ENGINEERING BOARD,

POPLAR RIVER TASK FORCE (1976)

* RECOMMENDED FLOW APPORTIONMENT IN THE POPLAR RIVER BASIN

The aggregate natural flow of all streams and tributaries in the Poplar River Basin crossing the International Boundary shall be divided equally between Canada and the United States subject to the following conditions:

1. The total natural flow of the West Fork Poplar River and all its tributaries crossing the International Boundary shall be divided equally between Canada and the United States but the flow at the International Boundary in each tributary shall not be depleted by more than 60 percent of its natural flow.

2. The total natural flow of all remaining streams and tributaries in the Poplar River Basin crossing the International Boundary shall be divided equally between Canada and the United States. Specific conditions of this division are as follows:

   (a) Canada shall deliver to the United States a minimum of 60 percent of the natural flow of the Middle Fork Poplar River at the International Boundary, as determined below the confluence of Goose Creek and Middle Fork.

   (b) The delivery of water from Canada to the United States on the East Poplar River shall be determined on or about the first day of June of each year as follows:

      (i) When the total natural flow of the Middle Fork Poplar River, as determined below the confluence of Goose Creek, during the immediately preceding March 1st to May 31st period does not exceed 4,690 cubic decameters (3,800 acre-feet), then a continuous minimum flow of 0.028 cubic metres per second (1.0 cubic feet per second) shall be delivered to the United States on the East Poplar River at the International Boundary throughout the succeeding 12 month period commencing June 1st. In addition, a volume of 370 cubic decameters (300 acre-feet) shall be delivered to the United States upon demand at any time during the 12 month period commencing June 1st.

      (ii) When the total natural flow of the Middle Fork Poplar River, as determined below the confluence of Goose Creek, during the immediately preceding March 1st to May 31st period is greater than 4,690 cubic decameters (3,800 acre-feet), but does not exceed

* Canada-United States, 1976, Joint studies for flow apportionment, Poplar River Basin, Montana-Saskatchewan: Main Report, International Souris-Red Rivers Board, Poplar River Task Force, 43 pp.

9,250 cubic decameters (7,500 acre-feet), then a continuous minimum flow of 0.057 cubic metres per second (2.0 cubic feet per second) shall be delivered to the United States on the East Poplar River at the International Boundary during the succeeding period June 1st through August 31st. A minimum delivery of 0.028 cubic metres per second (1.0 cubic feet per second) shall then be maintained from September 1st through to May 31st of the following year. In addition, a volume of 617 cubic decameters (500 acre-feet) shall be delivered to the United States upon demand at any time during the 12-month period commencing June 1st.

(iii) When the total natural flow of the Middle Fork Poplar River, as determined below the confluence of Goose Creek, during the immediately preceding March 1st to May 31st period is greater than 9,250 cubic decameters (7,500 acre-feet), but does not exceed 14,800 cubic decameters (12,000 acre-feet), then a continuous minimum flow of 0.085 cubic metres per second (3.0 cubic feet per second) shall be delivered to the United States on the East Poplar River at the International Boundary during the succeeding period June 1st through August 31st. A minimum delivery of 0.057 cubic metres per second (2.0 cubic feet per second) shall then be maintained from September 1st through to May 31st of the following year. In addition, a volume of 617 cubic decameters (500 acre-feet) shall be delivered to the United States upon demand at any time during the 12 month period commencing June 1st.

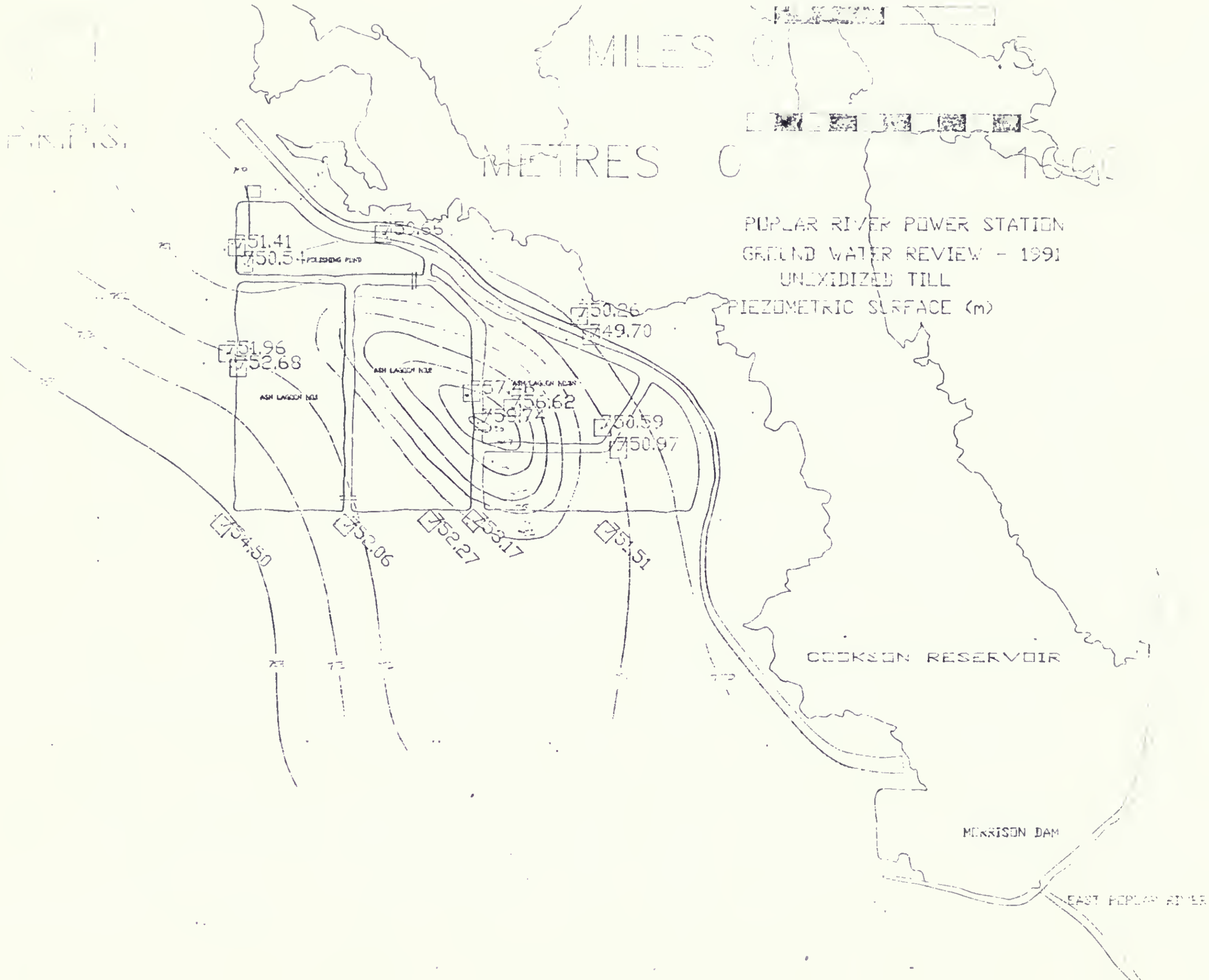
(iv) When the total natural flow of the Middle Fork Poplar, as determined below the confluence of Goose Creek, during the immediately preceding March 1st to May 31st period exceeds 14,800 cubic decameters (12,000 acres-feet) then a continuous minimum flow of 0.085 cubic metres per second (3.0 cubic feet per second) shall be delivered to the United States on the East Poplar River at the International Boundary during the succeeding period June 1st through August 31st. A minimum delivery of 0.057 cubic metres per second (2.0 cubic feet per second) shall then be maintained from September 1st through to May 31st of the following year. In addition, a volume of 1,230 cubic decameters (1,000 acre-feet) shall be delivered to the United States upon demand at any time during the 12-month period commencing June 1st.

(c) The natural flow at the International Boundary in each of the remaining individual tributaries shall not be depleted by more than 60 percent of its natural flow.

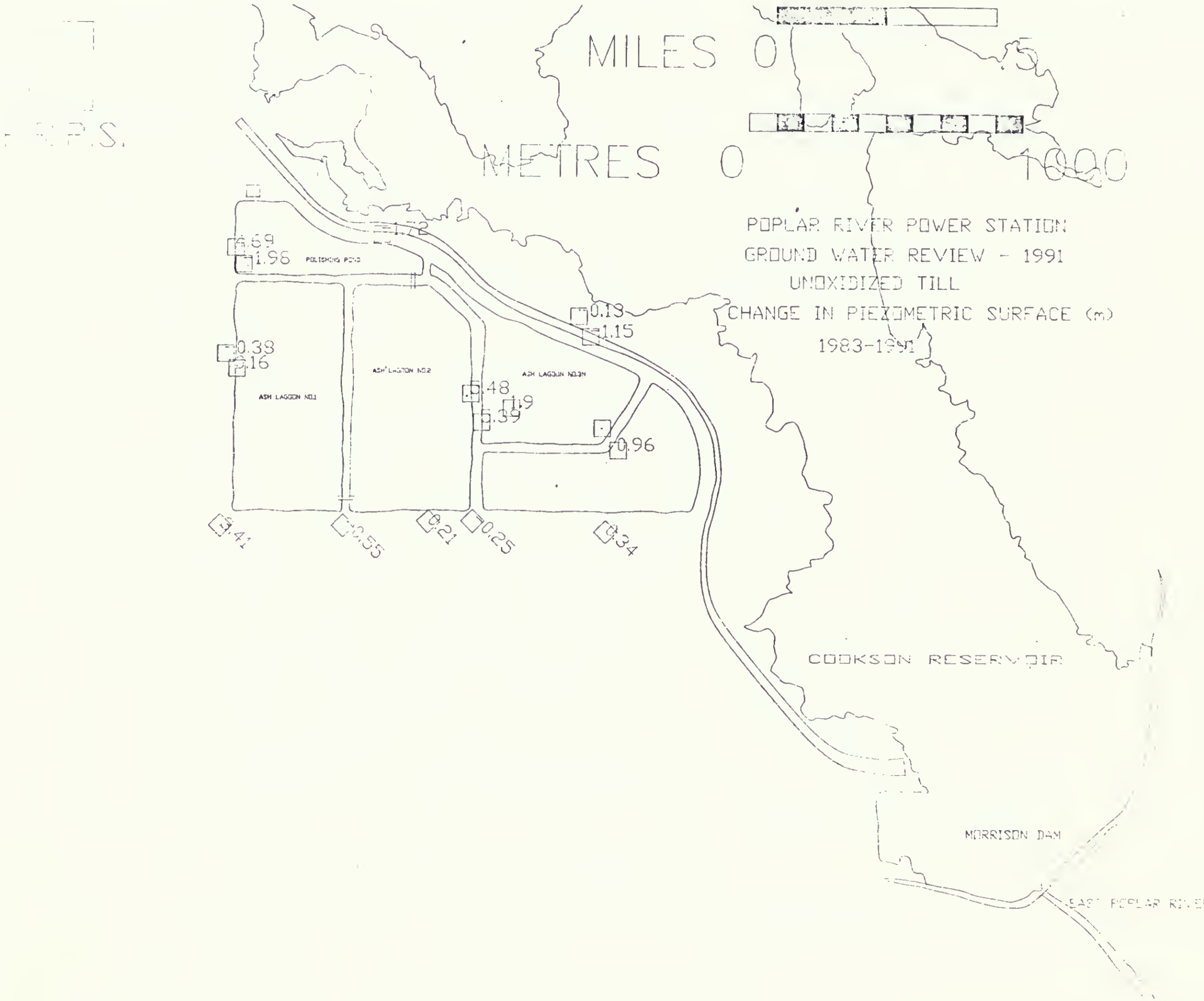
3. The natural flow and division periods for apportionment purposes shall be determined, unless otherwise specified, for periods of time commensurate with the uses and requirements of both countries.

ANNEX 5

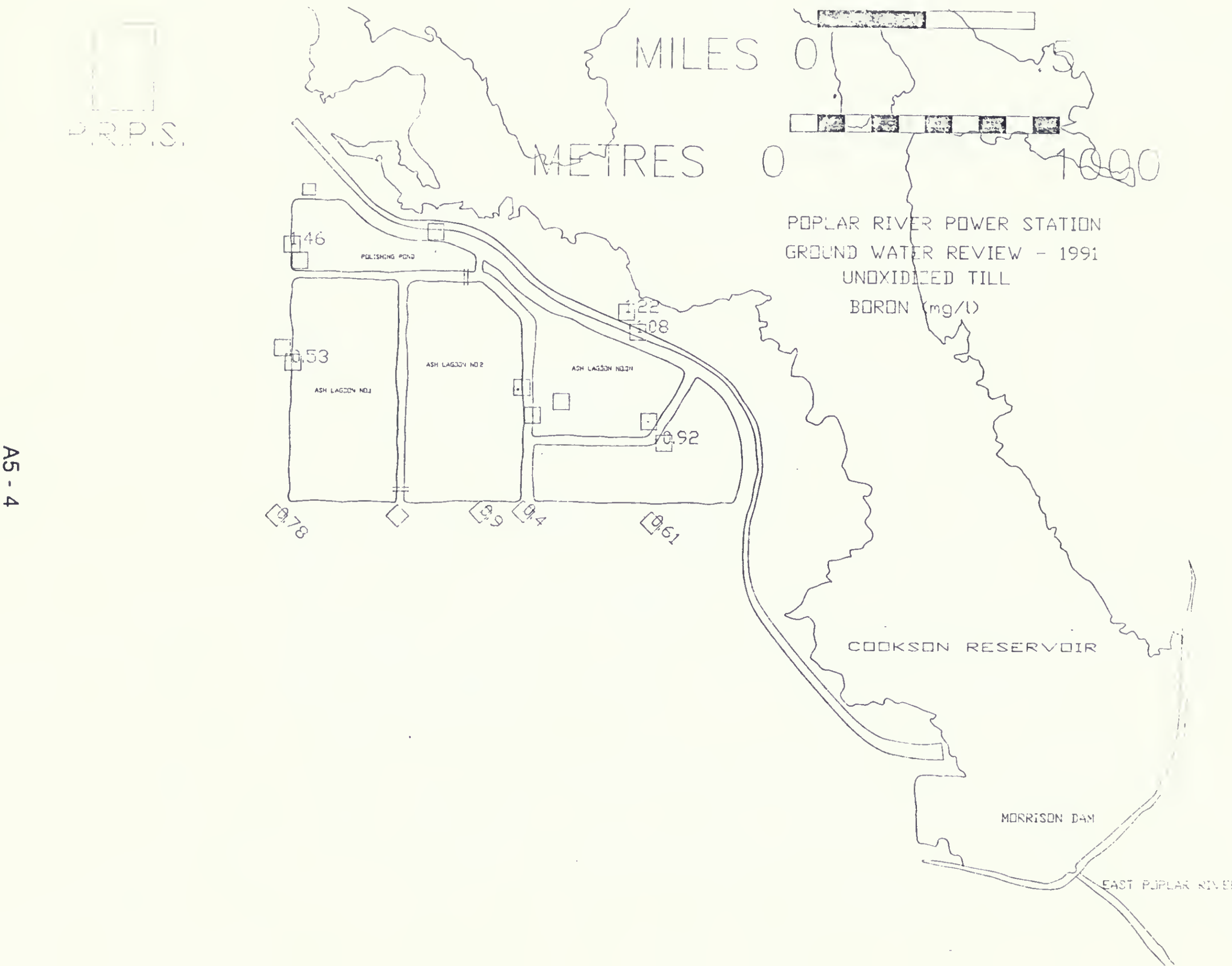
LEACHATE REVIEW



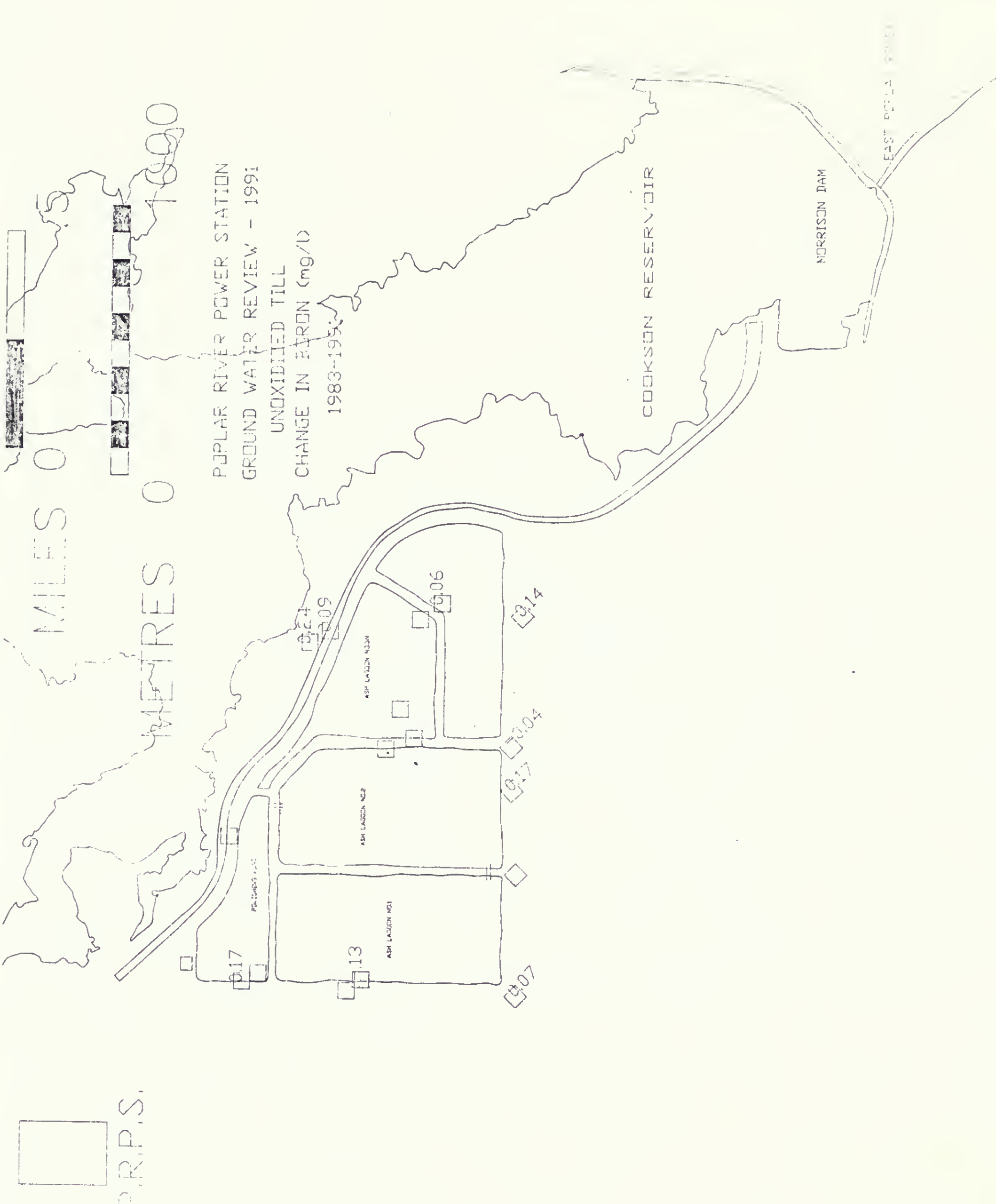
MILES 0
METRES 0
POPLAR RIVER POWER STATION
GROUND WATER REVIEW - 1991
UNOXIDIZED TILL
PIEZOMETRIC SURFACE (m)
750.65
751.41
750.5
POLISHING POND
751.96
752.68
ASH LAGOON NO.1
ASH LAGOON NO.2
750.26
749.70
757.46
756.62
759.74
750.59
750.97
754.50
752.06
752.27
753.17
751.51
COOKSON RESERVOIR
MORRISON DAM

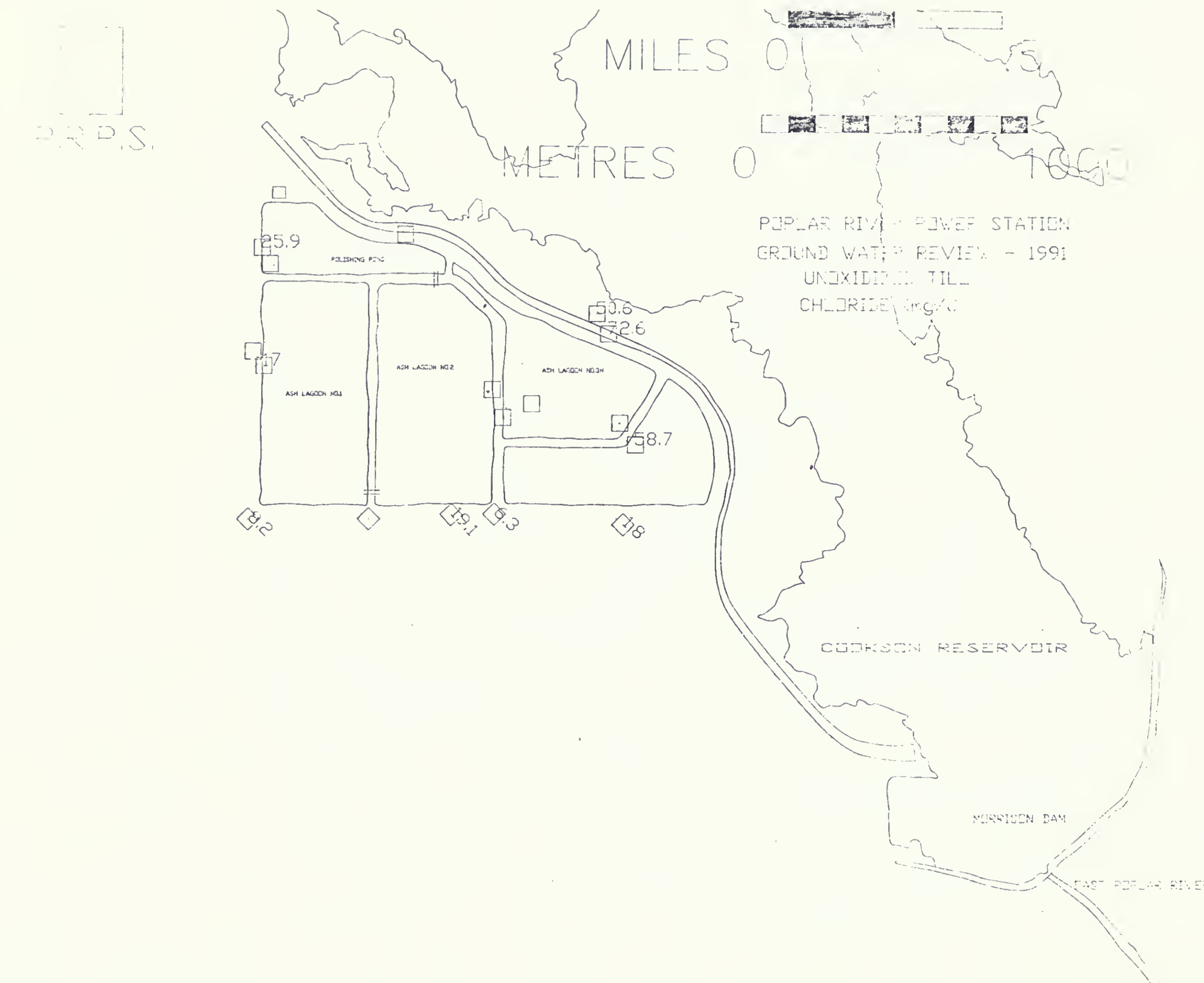


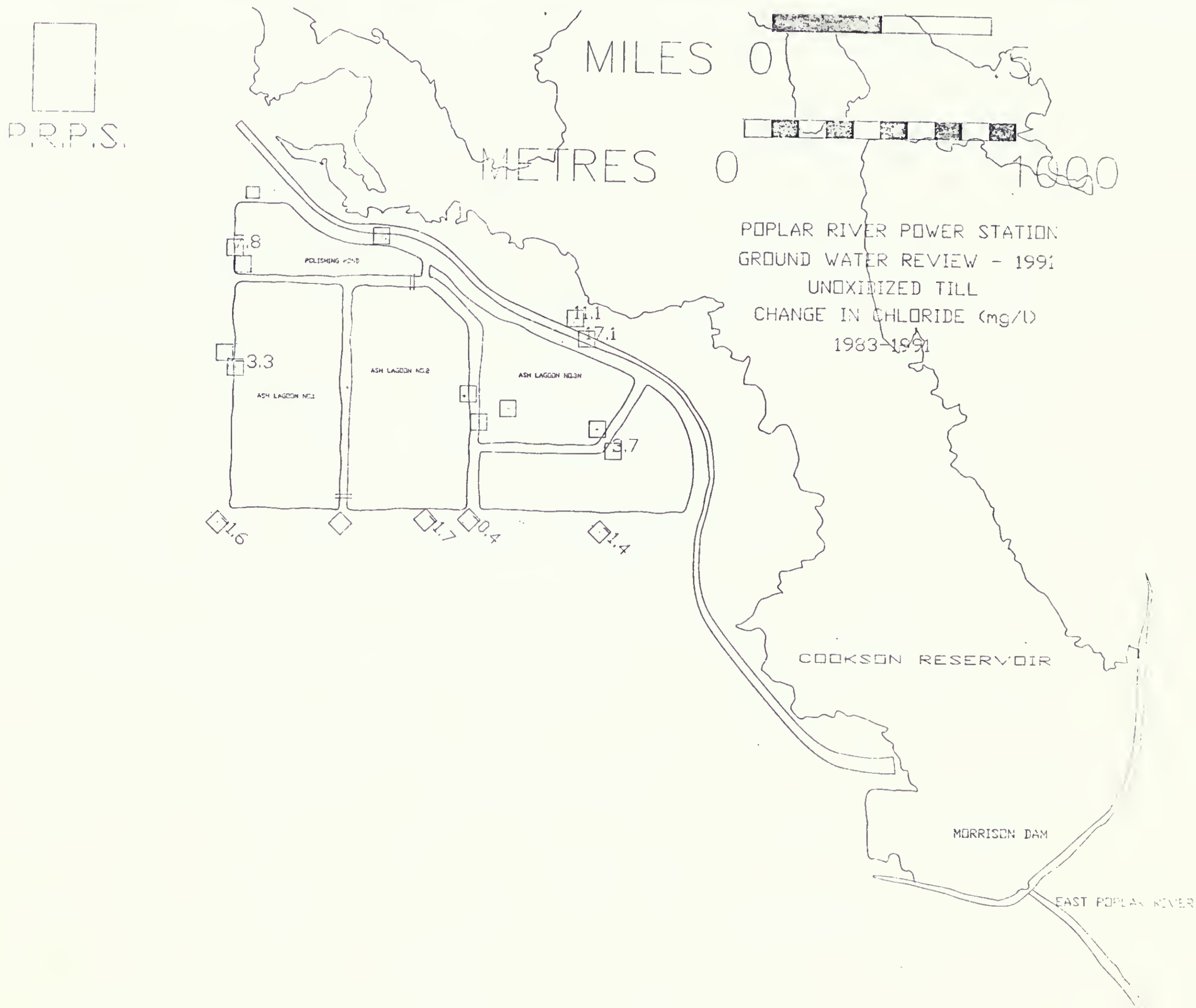
MILES 0 5
METRES 0 1000
POPLAR RIVER POWER STATION
GROUND WATER REVIEW - 1991
UNOXIDIZED TILL
CHANGE IN PIEZOMETRIC SURFACE (m)
1.96
0.13
1.15
0.38
0.96
0.55
0.25
COOKSON RESERVOIR
MORRISON DAM



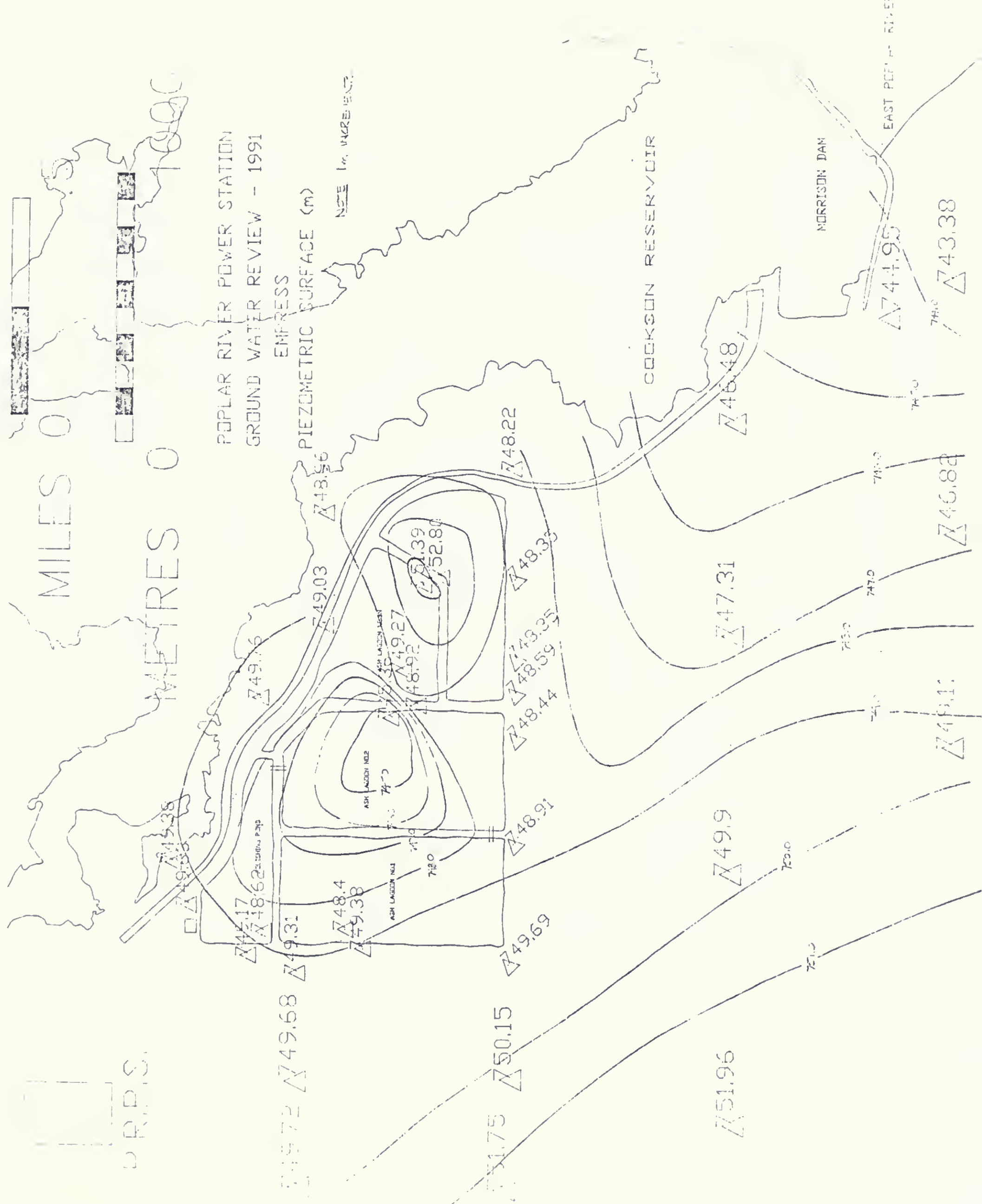
P.R.P.S.
MILES 0
.5
METRES 0
1000
POPLAR RIVER POWER STATION
GROUND WATER REVIEW - 1991
UNOXIDIZED TILL
BORON (mg/l)
POLISHING POND
ASH LAGOON NO 1
ASH LAGOON NO 2
ASH LAGOON NO 3
.46
0.53
1.22
1.08
0.92
0.78
0.9
0.4
0.61
COOKSON RESERVOIR
MORRISON DAM
EAST POPLAR RIVER

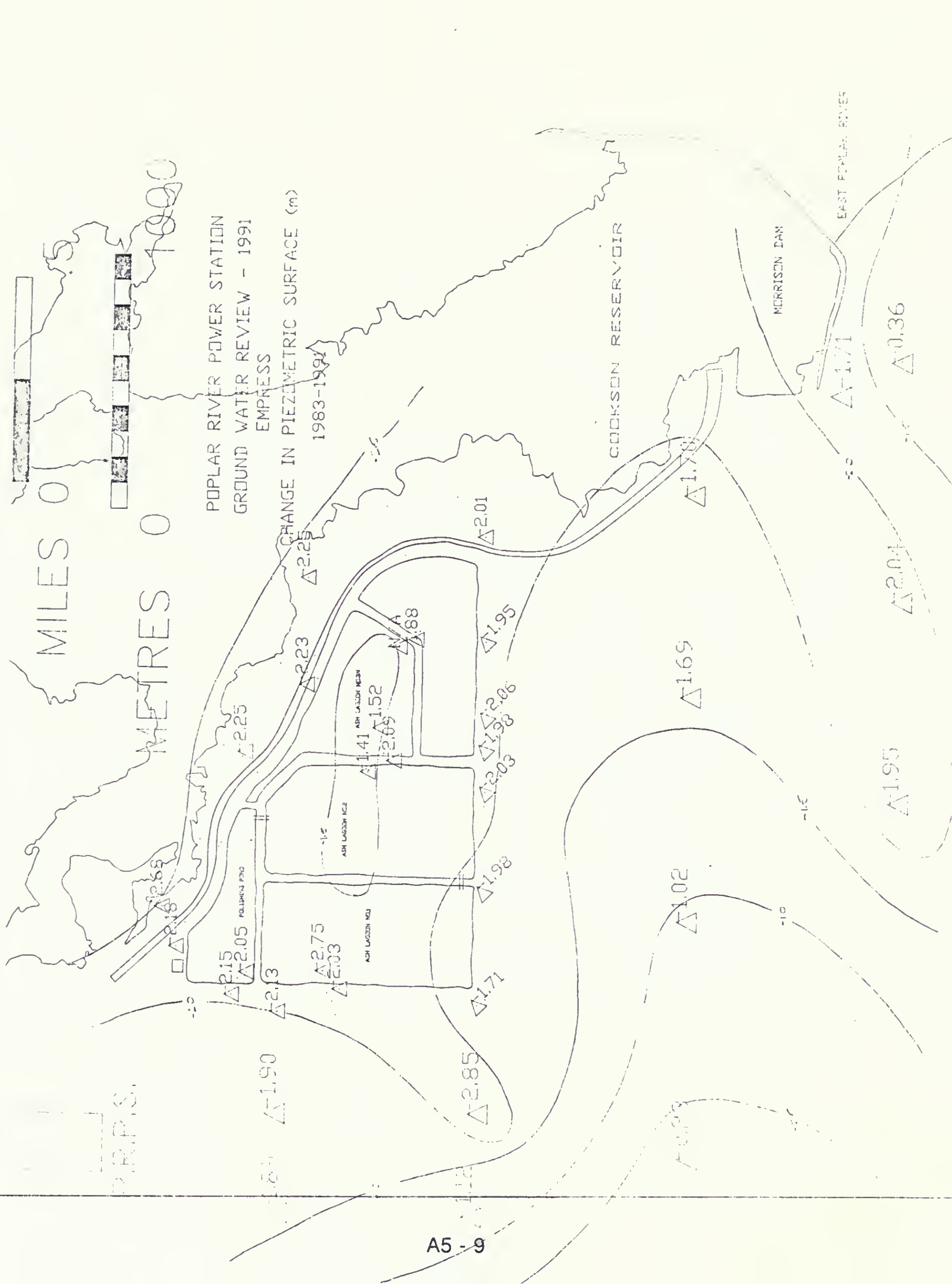

POPLAR RIVER POWER STATION
GROUND WATER REVIEW - 1991
UNOXIDIZED TILL
CHANGE IN BORON (mg/l)
1983-1991
MILES 0 .5
METRES 0 1000
COOKSON RESERVOIR
MORRISON DAM
ASH LAGOON NO.2
ASH LAGOON NO.1
0.06
0.14
0.24
0.09
0.04
0.17
0.17
.13
0.07
P.R.P.S.

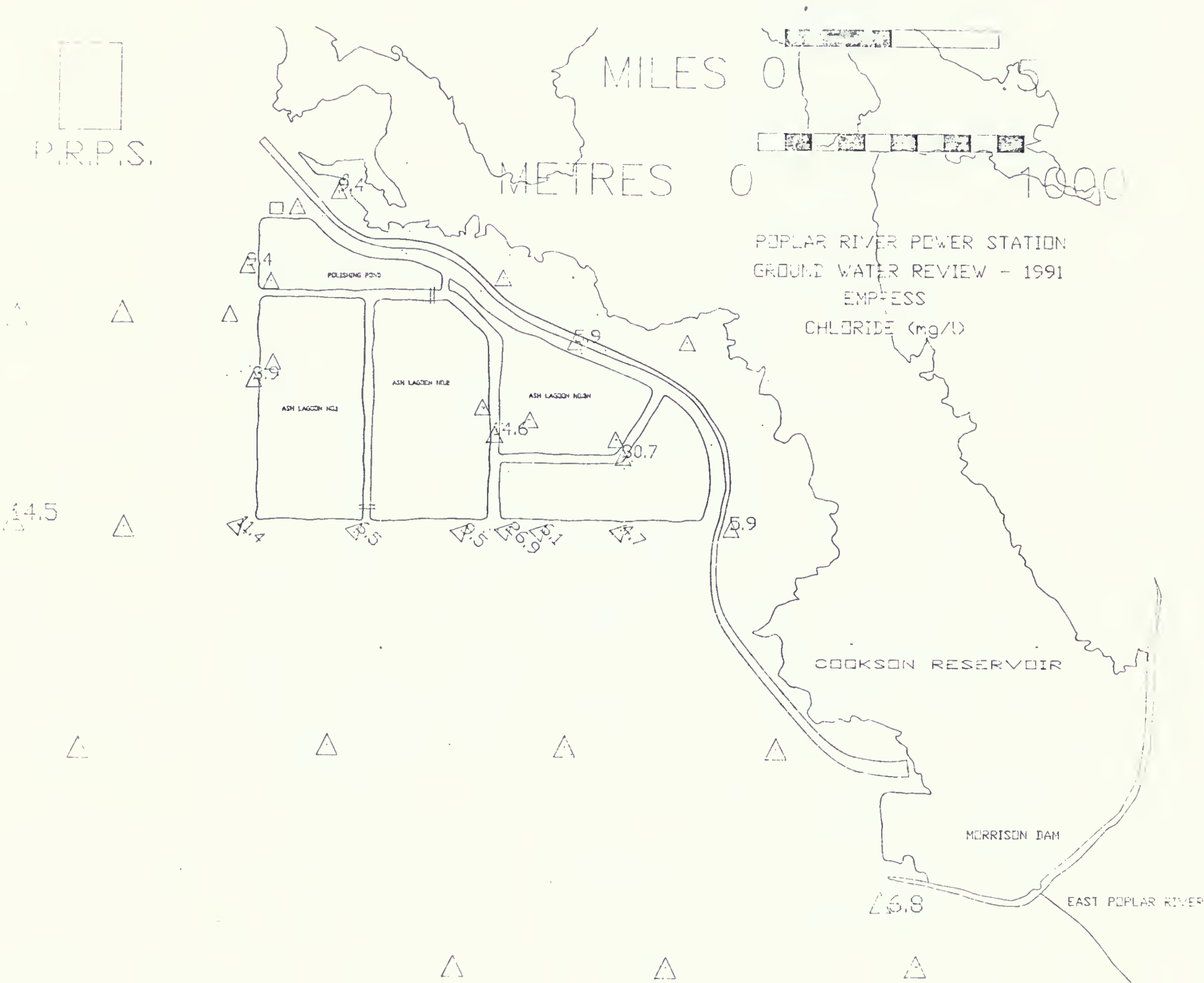

P.R.P.S.
MILES 0
METRES 0
GROUND WATER REVIEW - 1991
COOKSON RESERVOIR
MORRISON DAM
EAST POPLAR RIVER
POLISHING POND
ASH LAGOON NO.1
ASH LAGOON NO.2
ASH LAGOON NO.3N
25.9
60.6
72.6
58.7
6.3
19.1
8.2

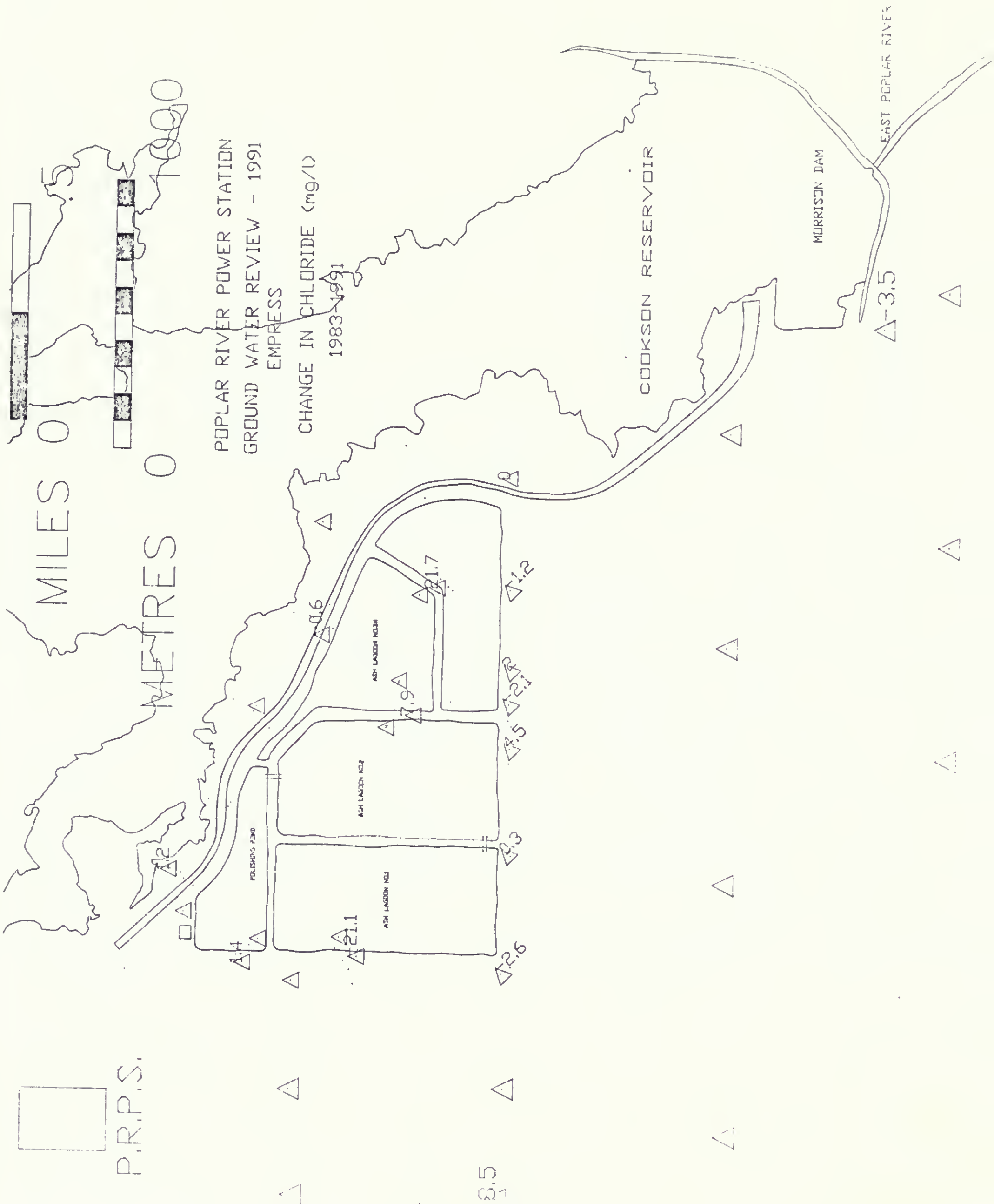


POPLAR RIVER POWER STATION
GROUND WATER REVIEW - 1991
UNOXIDIZED TILL
CHANGE IN CHLORIDE (mg/l)
1983-1991
MILES 0 .5
METRES 0 1000
P.R.P.S.
POLISHING POND
ASH LAGOON NO.1
ASH LAGOON NO.2
ASH LAGOON NO.3N
COOKSON RESERVOIR
MORRISON DAM
3.3
1.6
1.7
0.4
1.4
11.1
7.1
3.7

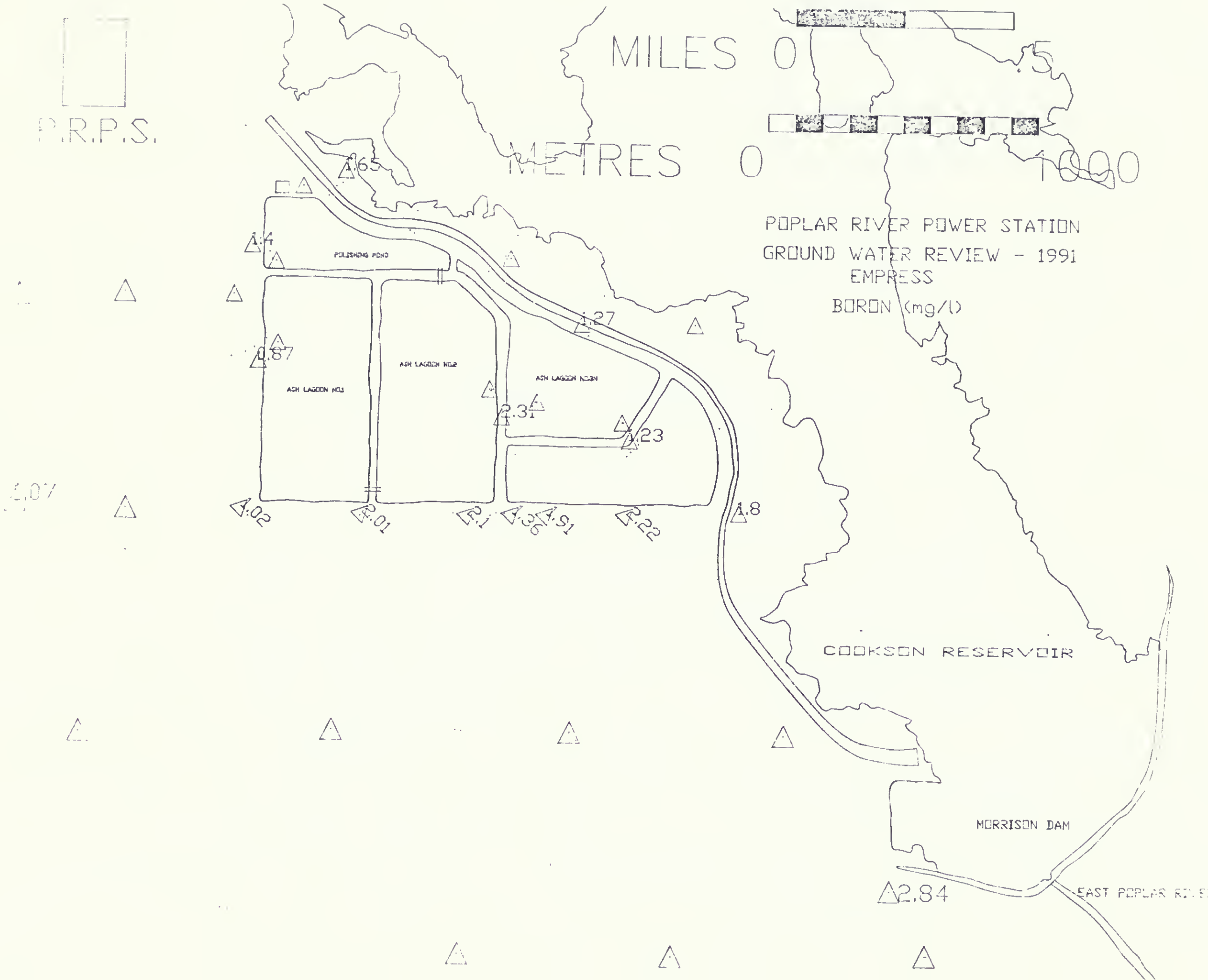

POPLAR RIVER POWER STATION
GROUND WATER REVIEW - 1991
EMPRESS
PIEZOMETRIC SURFACE (m)
COOKSON RESERVOIR
MORRISON DAM
MILES 0
METRES 0

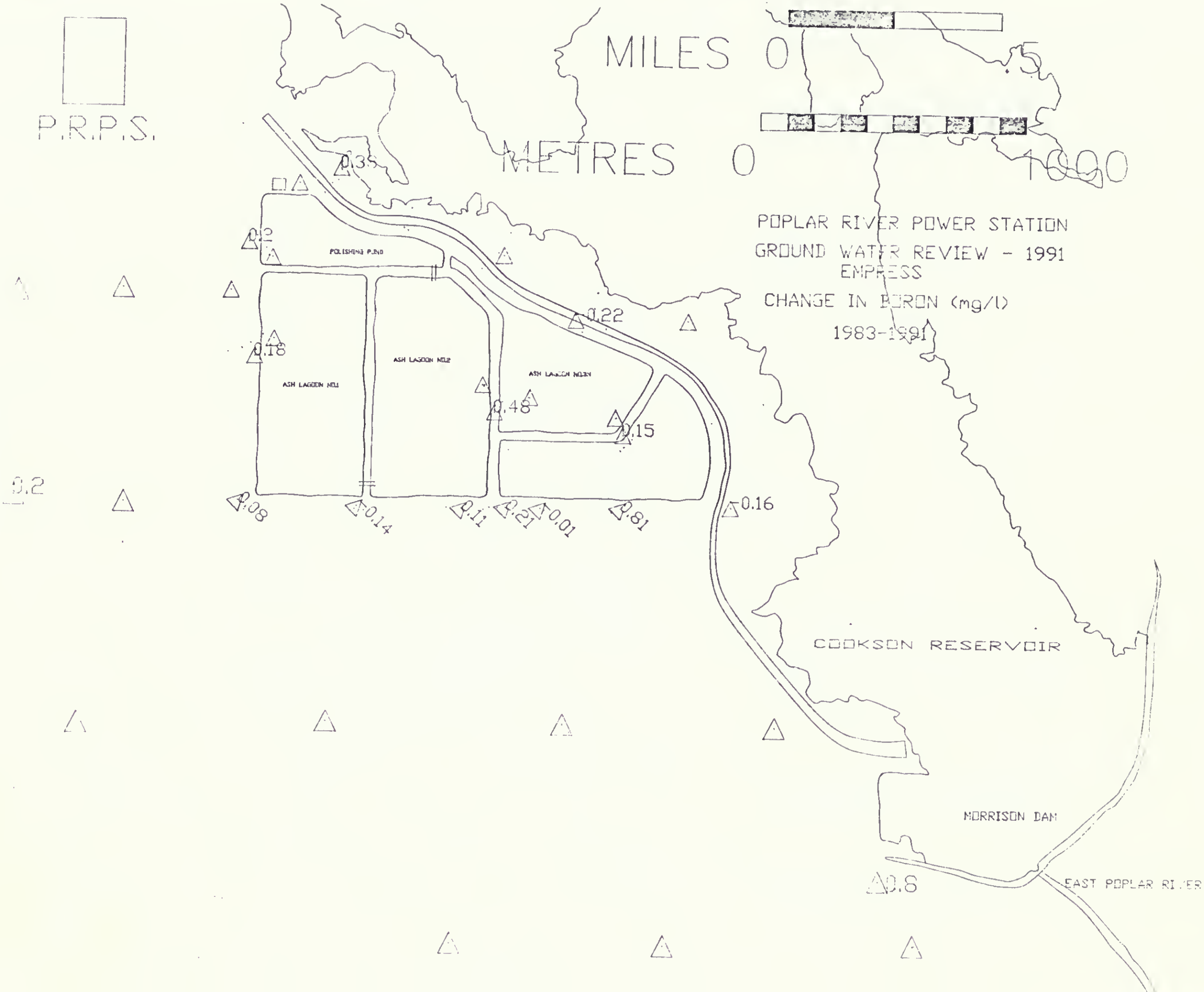

MILES 0 .5
METRES 0 1000
POPLAR RIVER POWER STATION
GROUND WATER REVIEW - 1991
EMPRESS
CHANGE IN PIEZOMETRIC SURFACE (m)
1983-1991
COOKSON RESERVOIR
MORRISON DAM
EAST POPLAR RIVER
ASH LAGOON NO.1
ASH LAGOON NO.2
POLISHING POND
P.R.P.S.

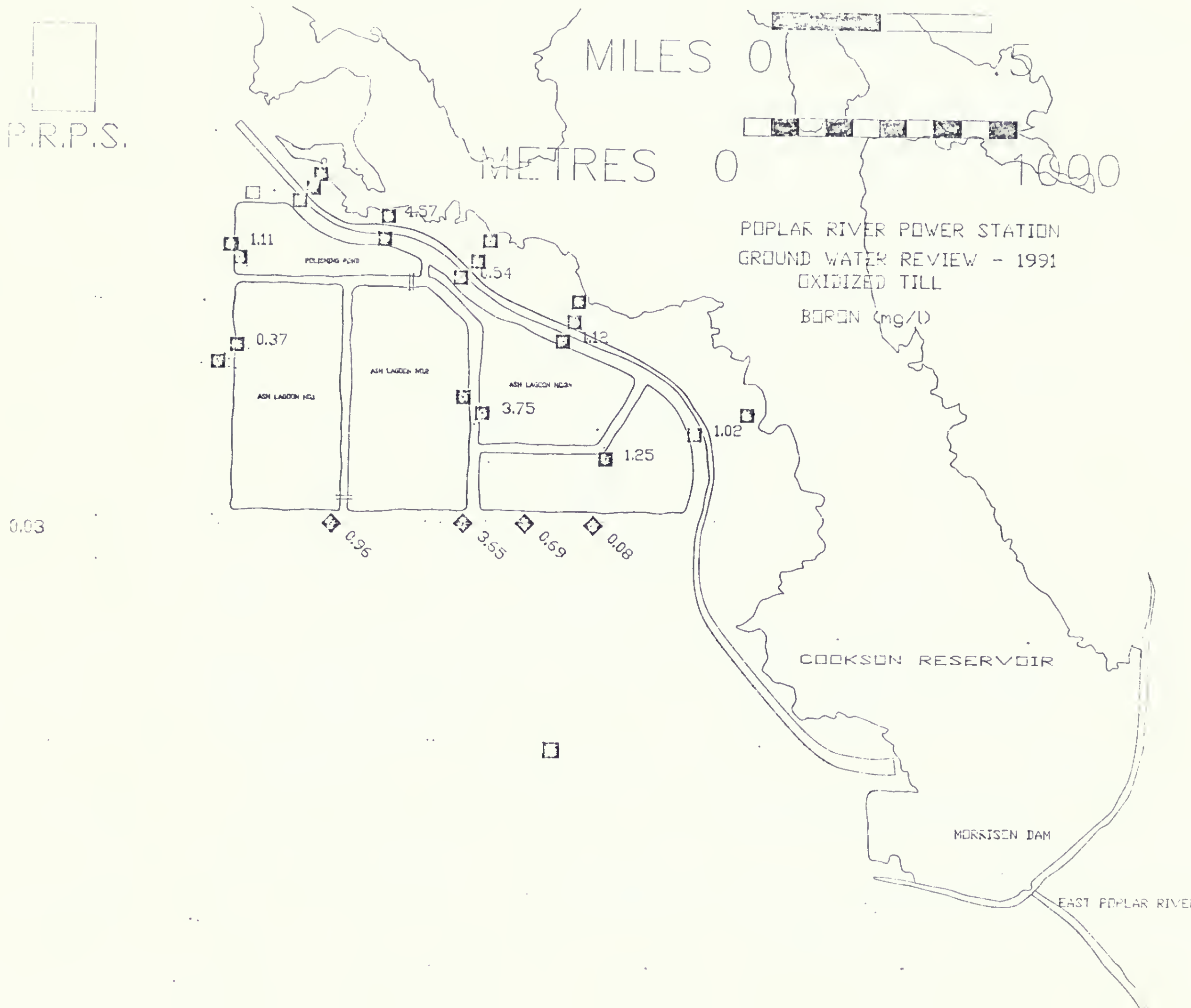

P.R.P.S.
MILES 0 .5
METRES 0 1000
POPLAR RIVER POWER STATION
GROUND WATER REVIEW - 1991
EMPRESS
CHLORIDE (mg/l)
POLISHING POND
COOKSON RESERVOIR
MORRISON DAM
EAST POPLAR RIVER
14.5
3.9
14.6
30.7
5.9
5.9
6.8



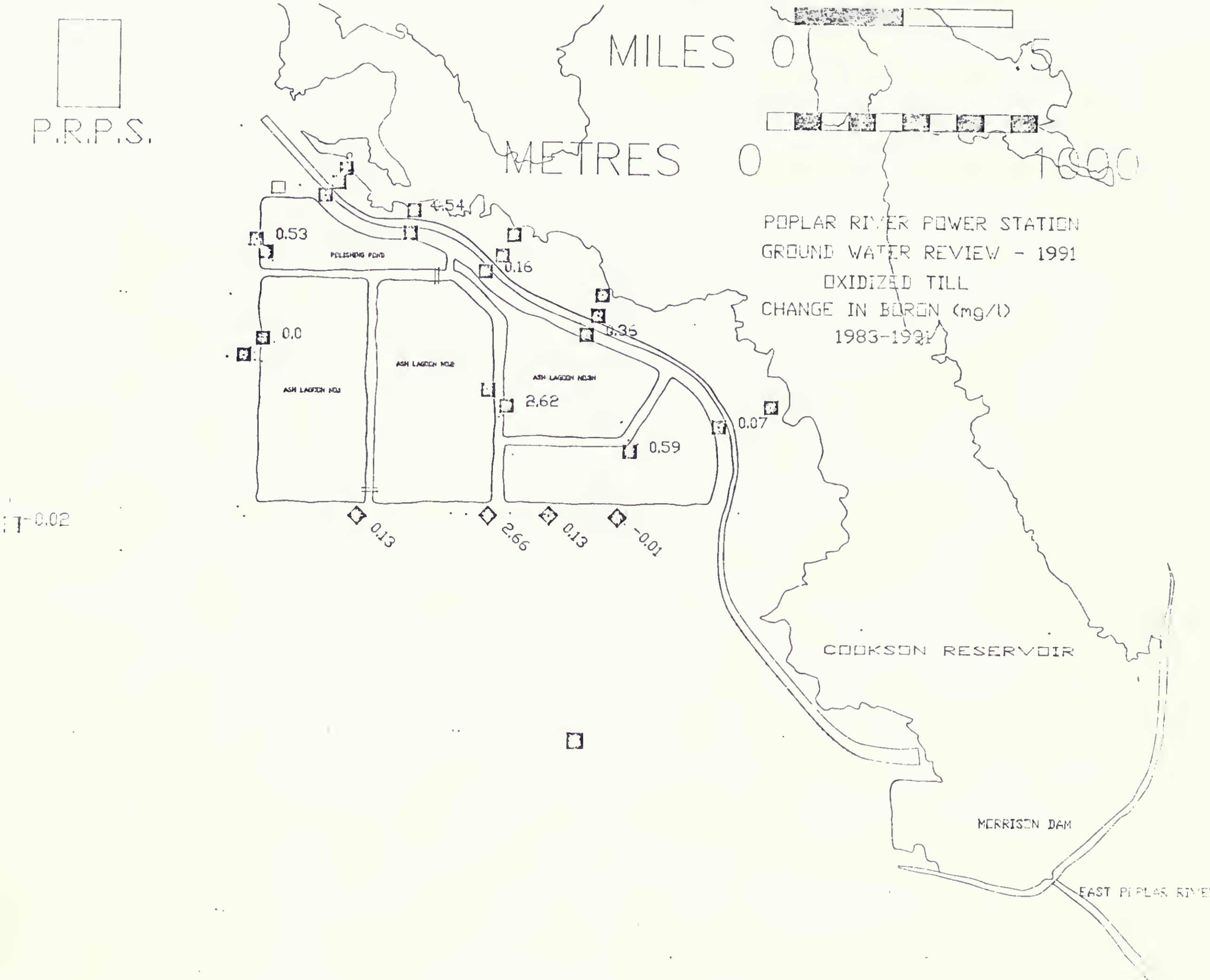
MILES 0 .5
METRES 0 1000
POPLAR RIVER POWER STATION
GROUND WATER REVIEW - 1991
EMPRESS
CHANGE IN CHLORIDE (mg/l)
1983-1991
COOKSON RESERVOIR
MORRISON DAM
EAST POPLAR RIVER
P.R.P.S.
POLISHING POND
ASH LAGOON No.1
ASH LAGOON No.2
ASH LAGOON No.3

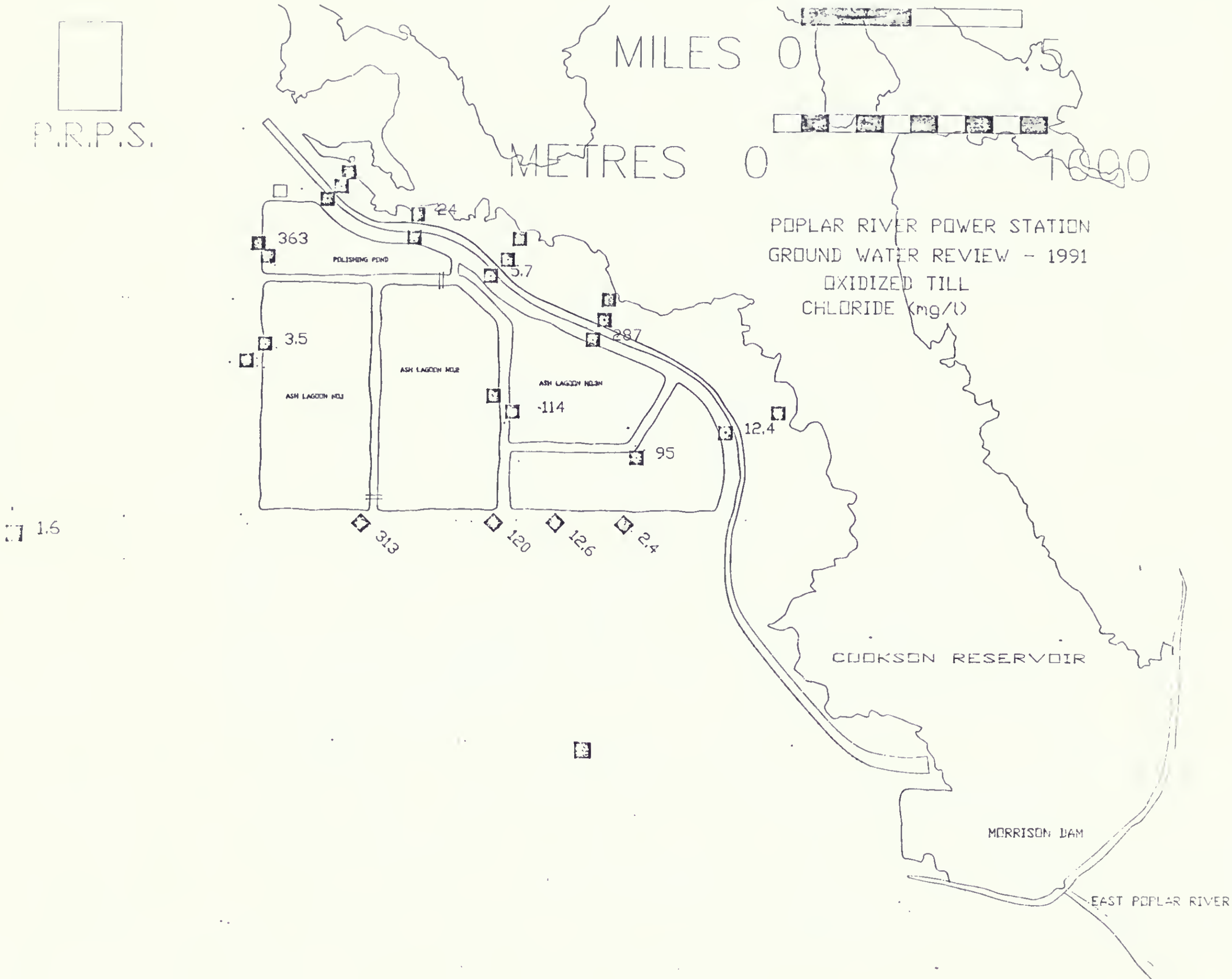

POPLAR RIVER POWER STATION
GROUND WATER REVIEW - 1991
EMPRESS
BORON (mg/l)
MILES 0 .5
METRES 0 1000
P.R.P.S.
POLISHING POND
ASH LAGOON NO.1
ASH LAGOON NO.2
ASH LAGOON NO.3N
COOKSON RESERVOIR
MORRISON DAM
EAST POPLAR RIVER
1.65
1.4
0.87
2.31
1.27
1.23
1.8
.02
2.01
2.1
.36
.91
2.22
2.84

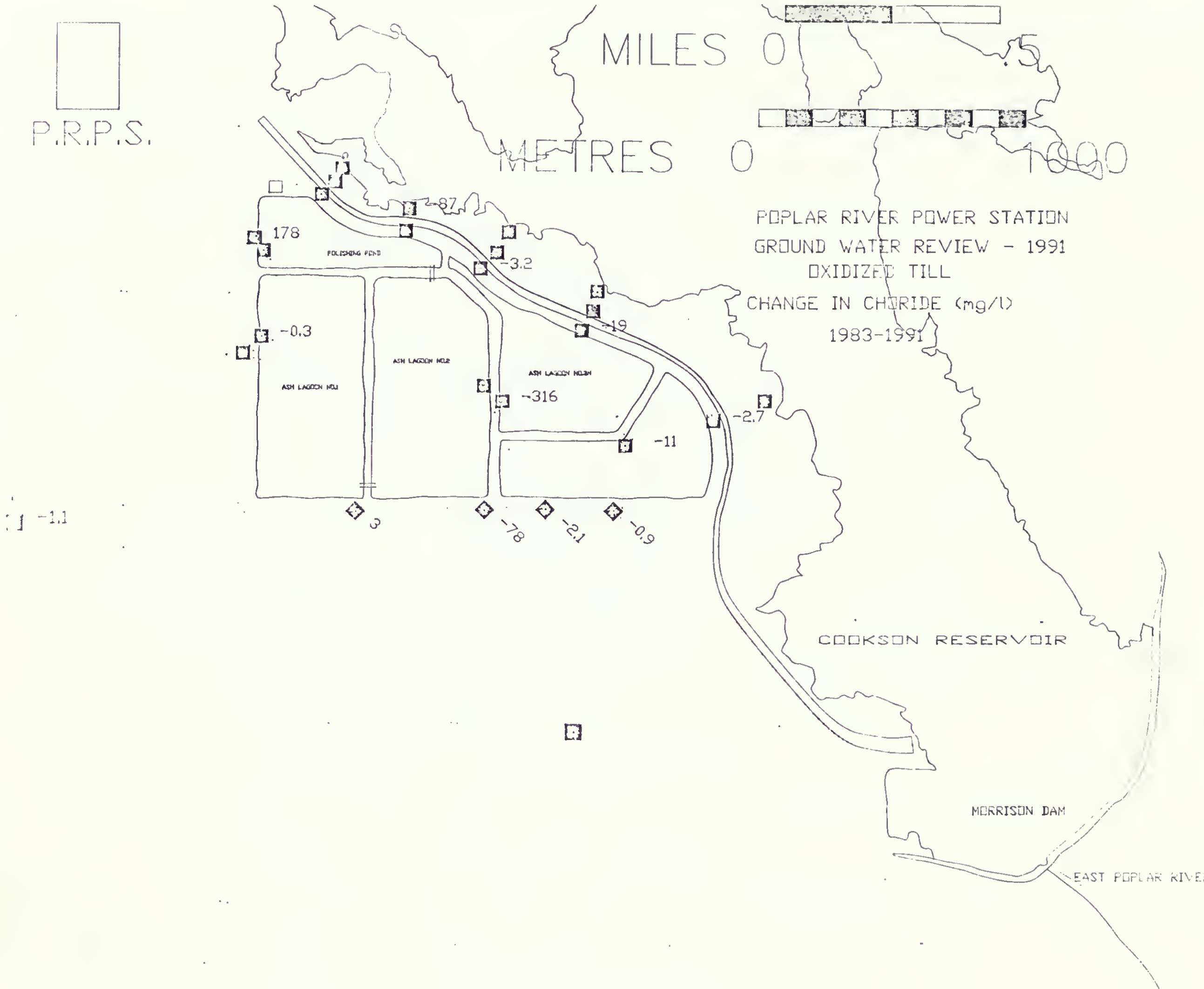

P.R.P.S.
MILES 0 .5
METRES 0 1000
POPLAR RIVER POWER STATION
GROUND WATER REVIEW - 1991
EMPRESS
CHANGE IN BORON (mg/l)
1983-1991
POLISHING POND
ASH LAGOON NO.1
ASH LAGOON NO.2
COOKSON RESERVOIR
MORRISON DAM
EAST POPLAR RIVER
0.35
0.2
0.18
0.48
0.22
0.15
0.16
0.08
0.14
0.11
0.21
0.01
0.81
0.8
0.2

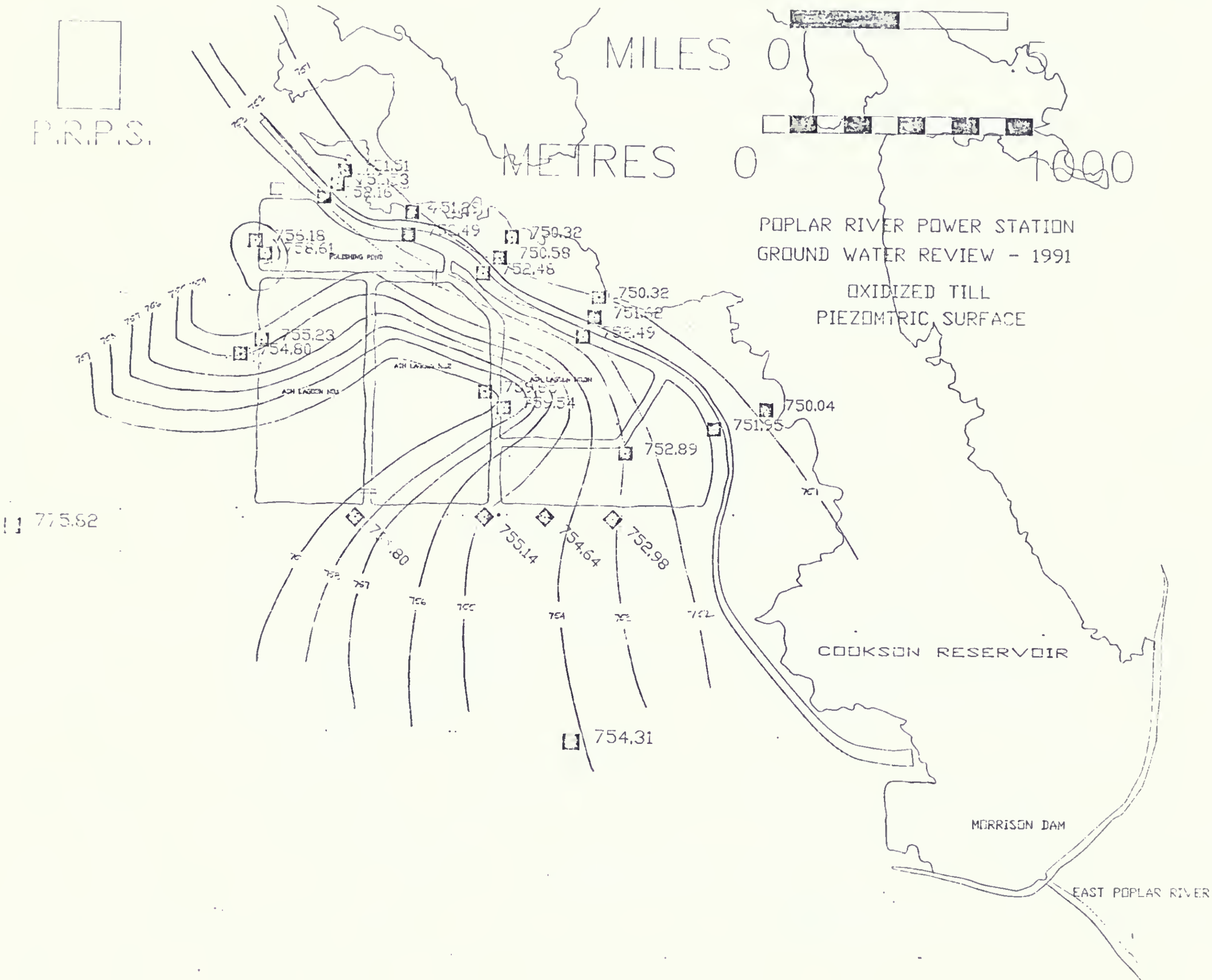


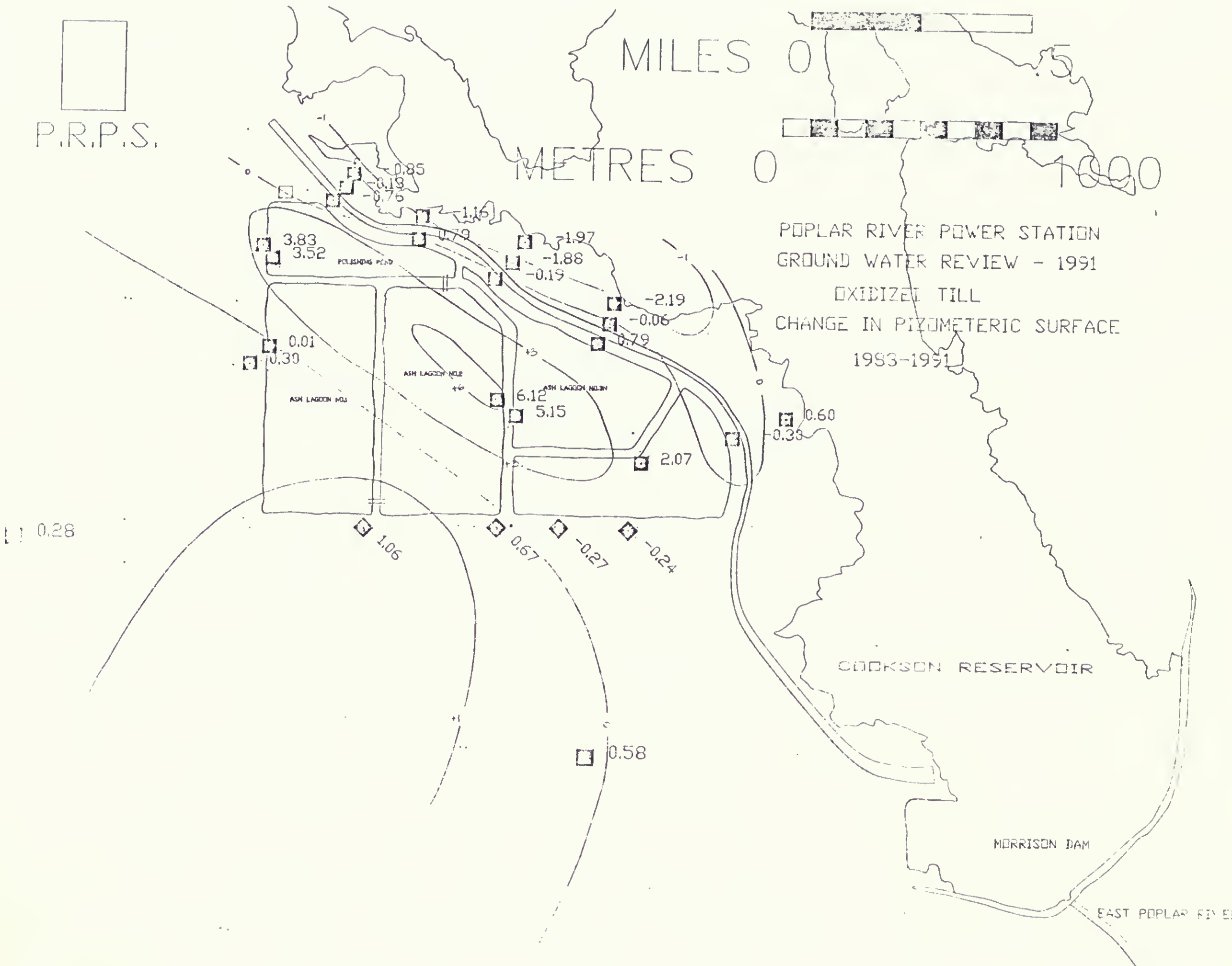
P.R.P.S.
MILES 0 .5
METRES 0 1000
POPLAR RIVER POWER STATION
GROUND WATER REVIEW - 1991
OXIDIZED TILL
BORON (mg/l)
4.57
1.11
0.54
0.37
1.12
3.75
1.02
1.25
0.96
3.55
0.69
0.08
0.03
COOKSON RESERVOIR
MORRISON DAM
EAST POPLAR RIVER


MILES 0 .5
METRES 0 1000
POPLAR RIVER POWER STATION
GROUND WATER REVIEW - 1991
OXIDIZED TILL
CHANGE IN BORON (mg/l)
1983-1991
P.R.P.S.
-0.02
POLISHING POND
ASH LAGOON NO.1
ASH LAGOON NO.2
ASH LAGOON NO.3N
0.53
0.0
4.54
0.16
0.36
2.62
0.07
0.59
0.13
2.66
0.13
-0.01
COOKSON RESERVOIR
MORRISON DAM
EAST POPLAR RIVER


POPLAR RIVER POWER STATION
GROUND WATER REVIEW - 1991
OXIDIZED TILL
CHLORIDE (mg/l)
MILES 0 .5
METRES 0 1000
P.R.P.S.
POLISHING POND
ASH LAGOON NO.1
ASH LAGOON NO.2
ASH LAGOON NO.3N
COOKSON RESERVOIR
MORRISON DAM
EAST POPLAR RIVER
363
24
5.7
287
12.4
95
114
3.5
313
120
12.6
2.4
1.6


P.R.P.S.
MILES 0 .5
METRES 0 1000
POPLAR RIVER POWER STATION
GROUND WATER REVIEW - 1991
OXIDIZED TILL
CHANGE IN CHORIDE (mg/l)
1983-1991
POLISHING POND
ASH LAGOON NO.1
ASH LAGOON NO.2
ASH LAGOON NO.3N
178
-87
-3.2
-19
-0.3
-316
-2.7
-11
3
-78
-2.1
-0.9
-1.1
COOKSON RESERVOIR
MORRISON DAM
EAST POPLAR RIVER


P.R.P.S.
MILES 0 .5
METRES 0 1000
POPLAR RIVER POWER STATION
GROUND WATER REVIEW - 1991
OXIDIZED TILL
PIEZOMTRIC SURFACE
COOKSON RESERVOIR
MORRISON DAM
EAST POPLAR RIVER
POLISHING POND
ASH LAGOON NO.1
750.32
750.58
752.48
750.32
750.04
751.95
752.89
755.23
754.80
756.18
752.98
754.64
755.14
754.31
775.62


P.R.P.S.
MILES 0 .5
METRES 0 1000
POPLAR RIVER POWER STATION
GROUND WATER REVIEW - 1991
OXIDIZED TILL
CHANGE IN PIZOMETERIC SURFACE
1983-1991
POLISHING POND
ASH LAGOON NO.1
ASH LAGOON NO.2
ASH LAGOON NO.3N
COOKSON RESERVOIR
MORRISON DAM
-0.85
-0.19
-0.76
-1.16
0.79
-1.97
-1.88
-0.19
-2.19
-0.06
0.79
3.83
3.52
0.01
0.30
6.12
5.15
2.07
0.60
-0.33
1.06
0.67
-0.27
-0.24
0.58
0.28

ANNEX 6

METRIC CONVERSIONS

METRIC CONVERSION FACTORS

ac	=	4,047 m^3 = 0.04047 ha
ac-ft	=	1,233.5 m^3 = 1.2335 dam^3
C°	=	5/9(F°-32)
cm	=	0.3937 in.
cm^2	=	0.155 in^2
dam^3	=	1,000 m^3 = 0.8107 ac-ft
ft^3	=	28.3171 x $10^{-3} m^3$
ha	=	10,000 m^2 = 2.471 ac
hm	=	100 m = 328.08 ft
hm^3	=	1 x 10^6 m^3
I.gpm	=	0.0758 L/s
in	=	2.54 cm
kg	=	2.20462 lb = 1.1 x 10^{-3} tons
km	=	0.62137 miles
km^2	=	0.3861 mi^2
L	=	0.3532 ft^3 = 0.21997 I. gal = 0.26420 U.S. gal
L/s	=	0.035 cfs = 13.193 I.gpm = 15.848 U.S. gpm
m	=	3.2808 ftm^2 = 10.7636 ft^2
m^3	=	1,000 L = 35.3144 ft^3 = 219.97 I. gal= 264.2 U.S. gal
m^3/s	=	35.314 cfs
mm	=	0.00328 ft
tonne	=	1,000 kg = 1.1023 ton (short)
U.S. gpm	=	0.0631 L/s

<u>For Air Samples</u>

ppm = 100 pphm = 1000 x (Molecular Weight of substance/24.45) mg/m^3